GEOLOGICAL SURVEY OF CANADA.

A. P. LOW, Deputy Head and Director.

THE BARYTES DEPOSITS

OF

LAKE AINSLIE AND NORTH CHETICAMP, N.S.

WITH NOTES ON THE

PRODUCTION, MANUFACTURE AND USES OF BARYTES IN CANADA.

BY

HENRY S. POOLE.

OTTAWA
GOVERNMENT PRINTING BUREAU
1907

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(SINCE 1885)

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859. Salt.
860. Zinc.
869. Mica.
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GEOLOGICAL SURVEY OF CANADA.

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A. P. LOW, Deputy Head and Director.

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CONTENTS.

A. P. Low, Esq.,
Deputy Head and Director,
Geological Survey of Canada.

DEAR SIR,—I beg herewith to hand you my report on the Geology of the Barytes deposits of Lake Ainslie and North Cheticamp, N.S., with notes on the Production, Manufacture and uses of Barytes in Canada.

I am, Sir,
Your obedient servant,

HENRY S. POOLE.

OTTAWA.

INTRODUCTION.

BARYTES.

Barite, Heavy Spar, Barium Sulphate, Tiff, Cawk, Cauk.

Composition.—$BaSO_4$; with a hardness of 2.5 to 3.5; and a high specific gravity, 4.3 to 4.6, which gives it the common name of Heavy Spar. It is white or stained some light tint, more frequently reddish, by iron. It is heavier than and not nearly so hard as quartz. It is harder than gypsum and it is readily distinguished from limestone and marble by its greater specific gravity and by its not effervescing in acids. As a mineral it may contain small amounts of iron, alumina, magnesia or lime, with one to three per cent of silica. It crystallizes in the orthorhombic system. Barium carbonate or Witherite is exceedingly rare in Canada.

Among useful minerals barytes is looked at askance as a cheap make-weight and impurity. The intrinsic merit which it undoubtedly possesses in certain of the arts is obscured by the public knowledge of its general employment as an adulterant. It differs in this respect from some other substances at times used in a similar manner, yet without the same attached stigma. The character of starch, for example, is not smirched by its use to dilute mustard and cocoa.

Occasion will be taken in this Bulletin to accentuate this point and mention will be made of several industries in which barytes is used for its acknowledged good qualities and not as a surreptitious, inferior substitute.

With the grade of each class of goods subjected to adulteration it remains a moot point where effective treatment ends and imposition begins. A tacit agreement seems to permit trade names giving to terms a meaning at variance with that of common parlance. The Inland Revenue Department undertakes to restrict an extension of this practice and analyses in its laboratories various samples of manufactured substances whose composition is not readily detected by inspection.

The highly poisonous nature of its base, barium, is so well locked up in the insolubility* of this compound that no danger results from its use; it can be handled and breathed and swallowed with the modicum of detriment that accompanies contact with any substance, inert and not benign.

The Genesis of Barytes.—Cumulative researches in the laboratory of the Geological Survey at Washington, D.C., have included computative and mean results of the relative abundance of the primary elements of matter in the primitive rocks of the earth's crust, eruptive and crystalline.

These investigations have led to the discovery that although barytes is practically insoluble barium in perceptible quantities is almost universally diffused in igneous rocks. On an average of over 600 determinations of rocks of this class the percentage of baryta was found to be 0.11, equalling manganese oxide 0.10, and the chemical elements, sulphur 0.108 and phosphorus 0.11. To these elements a closer comparison of quantities may be made by giving the amount of barium 0.089 and manganese 0.084 in their elementary state.

On the other hand a composite analysis of equal weights of over 800 samples of limestone failed to detect even a trace of barium, while a similar treatment of 250 samples of sandstone, a sedimentary rock, showed an average content of 0.05 of baryta. It would then seem that while barytes and calcspar often are both constituents of a mineral vein, the circumstances of deposition of limestone in mass are not suitable to the dissemination through it of minute depositions of barytes.

The conclusion derived from the composite analysis would thus imply the primary source of barium to be direct from the primitive rocks of the earth's crust in which, as shown by a large number of laboratory tests, an appreciable quantity exists. From the same source also come chlorides, and the sequence of reactions which the chemical affinities of these substances require, suggests why deposits of the insoluble sulphate should be looked for in clastic rocks of an eruptive region and in such rocks as the felsites of Lake Ainslie, which are of igneous origin and are deposited around the immediate centres of ancient volcanic activity. Pertinent to this inquiry is the presence of baryta and strontia in a great number of the saline waters of Canada. In the springs of Varennes, St. Léon, and Lanoraie, the precipitates obtained were found to be mixtures of the barium and strontium sulphates. In the last named spring there was detected 0.03 of barium chloride in 1000 parts of water with a further

*Though totally insoluble in acids barium sulphate is partly soluble in sodium hyposulphate.

addition of .01 of barium carbonate. The chemical history of these and other mineral waters was fully discussed in The Geology of Canada, 1863, pp. 550-3.

How a mineral so inert and so unaffected by chemical re-agents in the wet could be so universally disseminated is partly illustrated by a growth, in some coal mines of the north of England, of soft layers of barytes in the water-troughs and pipes. In these pits the mine water contains barium chloride, and when the pyrites, present in the coal, decomposes on exposure to the air in the workings, free sulphuric acid is generated and there is a consequent precipitation of barium sulphate.

The chemist Bischoff states that barytes* can be decomposed by heated solutions of alkaline carbonates and that when these are cooled it is reformed and deposited. Dawson suggests that it has probably been introduced in this manner into the vein at Five Islands in Nova Scotia.

In connexion with the marked insolubility of barytes in the laboratory of the chemist it may be noticed in the field that the outcropping mineral which has been exposed to the weather for untold ages has a very uneven surface, the layers, patches and streaks of greater opacity standing out above the level of the more crystalline and friable mineral.

CHAPTER 1.

OCCURRENCE.

Where barytes accompanies metallic ores as the gangue of a vein it does not as a rule occur in commercial quantities. Where it has been worked for the mineral itself it has generally been found in pockets or lenses, often in limestone or along an unconformable contact with associated rocks, the pockets being sometimes distinct from each other or connected by a small leader. The ore sometimes occurs in limestone merely as nodules. Many illustrations of a scattered accompaniment may be found in the Reports of the Geological Survey of Canada, as for example in the writings of Mr. H. Fletcher† and in the Mineralogy of Nova Scotia by Professor H. How, edition 1869‡, the first comprehensive

*Geological Observer De la Beche, p. 768.

†Vol. V., 1889-91, Part P, pp. 175 (River John), 176 (Londonderry), 185 (Tennycape) and 192 (Five Islands).

‡H. How, pp. 111-113 (Manganese of Tennycape); 116 (Manganese of Onslow); 91 (brown hematite beds, Londonderry).

handbook on Nova Scotian minerals ever issued, and a fruitful source of information for subsequent writers on that subject.

ONTARIO.

Among the earlier references to barytes are those of Sir W. E. Logan in his Geology of Canada, 1863, where he mentions (pages 458 and 771) occurrences in the second lot of range viii (or vii) of Lansdowne; in lot 4 of range vi of Bathurst township; in MacNab at the mouth of the Dochert; in cavities of the Laurentian limestone near the hematite of Iron island, Lake Nipissing; in the Gaspé sandstones of the York river and in the veinstones of the large lodes carrying copper ores, on the north side of Lake Superior, between Pigeon river and Fort William, and in Thunder bay.

In the last locality the mineral, with green octahedral fluor-spar lines, intersects a porphyry*. For many years past this mine has not been worked.

Barytes has been found crystallized in geodes in the dolomites of the Calciferous formation and occasionally in those of the Niagara at the falls, and as small almond-shaped masses of a reddish cleavable variety, with gypsum, in shales of the Hudson River formation at Cape Rich on the southwest side of Georgian bay.

The Annual Mineral Resources of the United States refers to barytes works on the American side of the Niagara falls with a capacity of sixty tons a day, which at one time drew part of their supply from the north shore of Lake Superior.

Other barytes veins occur on the adjacent islands: the principal one is on McKellar island.

The vein was discovered in 1869 by Messrs. McKellar Bros. It is very large, consisting of coarsely crystalline calcite and barite, occurring in separate ribs for the most part, although they are mixed in part of the vein. There is also a small proportion of quartz, generally colourless. The metallic minerals consist of zinc blende with a little galena and pyrites. In addition to the main vein, which is composed of solid spar, and is about sixty feet wide, there are on the south side of the island numerous side stringers intersecting the country rock of the west wall

*The vein is ten feet thick, and has been worked for silver to a depth of about 150 feet.

of the vein. The enclosing rock is a dark green coarse-grained trap. This composes the whole island, which is only some eight or nine chains wide. During the summer of 1886 the barite rib on the east side of the vein was worked down from the surface, some thirty men being employed at this work, and the product, after handpicking to extract as much of the calcite and quartz as possible, was shipped to the United States, the purchasing firm giving $5 over the rail at the island for the best quality.*

According to the Descriptive Catalogue for the Colonial Exhibition, the principal deposit of barytes on the northwest shore of Lake Superior is on McKellar island, which is one mile south of Pie island. The vein is forty-five feet in width, of which one-third consists of white barytes in bands of from two to six feet, running parallel to the walls of the vein, while the rest of the vein is crystalline calcite holding argentiferous galena and native silver. This deposit in 1890 was operated by the United States Barytes Company of Cleveland, Ohio. The Canadian production of barytes that year amounted to 1,842 tons, valued at $7,543, obtained from two deposits, the main one being the McKellar Island vein. Almost the whole of the production was exported to the United States. (Mineral Statistics and Mines for 1890). In 1894 the mine had been purchased by Messrs. Barnes and Upton of Duluth. The ore was tested and several hundred tons used with good results (Ontario Bureau of Mines Report for 1894). The following year the deposit had been purchased by Mr. W. P. Lardner of Duluth, and associates. It was said that results of tests of the barytes were very satisfactory. (Ontario Bureau of Mines Report, 1895).

About four miles north of Kingston city, on the road thence to Elginburg, a vein of barytes, with a width varying from a few inches to over three feet, is said to extend from the road to Sydenham on the east in a northwest direction as far as Varty lake, a distance of nearly fourteen miles. At the eastern end it is well exposed on lots 17–18, R. IV, Kingston township, and has been traced for a short distance southeast, across the Kingston road. In a northwest direction it has been uncovered on the south half of lots 16 and 15, R. V. The vein is nearly vertical and cuts across the limestone formation of the district, which lies in nearly flat strata and is similar in character to that of the city of Kingston, usually regarded as of Black River age or possibly a portion of the upper Chazy, since the rocks lie beneath the beds which hold the large and characteristic Black River fossils so common to the formation. The limestone is usually a somewhat hard and cherty rock with dark shaly partings. The mineral is found in a long, straight

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*Geol. Sur. of Can., Vol. III., pt. H., p. 42.

fissure and is usually of a dirty white colour, the contact with the limestone or sides being sharply defined and the barytes containing a small admixture of carbonaceous matter, probably anthraxolite, along the margin. The vein has been opened on lot 17, R. IV, to a depth of about twenty feet and about 100 tons have at different times been taken to Kingston for shipment. In places the barytes is mixed with calcite and in one of the pits, at a depth of about eighteen feet, the mineral was almost entirely replaced by the calcite. There appears to be a large amount of the mineral in this vein, but the somewhat impure character of the ore has apparently interfered with its development.

Barytes also occurs, in Ontario, in the Laurentian rocks of Lanark county in the township of North Burgess, lot 4, range IX; of Packenham, lot 3, range XI; of Lavant, lot 22, range I; of Ramsay, range IV; also at Dog lake, Stormington, Frontenac county and at Galway in Peterborough county. It occurs in the Cambrian rocks in Ontario in the second cutting west of McKay harbour on the C.P.R., in the district of Thunder bay; in Oso, Frontenac county; in Lansdowne and North Crosby, both in Leeds county; in Bathurst and in Lavant, both in Lanark county and in Madoc, lot 15, range VI, Hastings county.

QUEBEC.

Barytes has been found in the province of Quebec, in the Saguenay valley; in Wright county, near Perkins Mill, range XII, lot 12; at the Haycock mine in Templeton where crystals of barytes are associated with specular iron, calcite, beautiful green fluor-spar and reddish feldspar and in Buckingham township, range IV, lot 21, Labelle county, where some of the exposures of the limestone are intersected by veins of opaque white barytes, holding galena. One vein is from six to fourteen inches wide with two strings of galena, of a width, where exposed, of one inch and one inch and a half, with an underlie N. 40° E. $<72°$. Another vein of the same character lies thirty paces westward. It is six inches wide with less galena, and on a course S. 53° E. was exposed for sixty feet. Still another vein of barytes was exposed 250 paces northeastward of the first mentioned, with a course N. 54° W.*

A vein of barytes nine inches wide has been found at Anse à la Vieille, in Bonaventure county.

In Wright county, on the west half of lot 7, in concession 10 of the township of Hull, four miles from the Gatineau river, the Canada Paint

*Geol. Sur. Report for 1863-66, pp. 19, 20.

Co. followed a vein for 300 feet in a N.N.W. direction, and worked it to a depth of twenty feet. In 1899 the Company took out of the Foley mine 416 tons of barytes and in 1900 about 460 tons, valued at $3,220. The vein is in the Laurentian system and varies from two to four feet in width. The country rock is a very crystalline white limestone, dipping at a high angle S. 67° E. The barytes is of an opaque white colour, associated with sea-green fluor-spar. This spar is hardly in a sufficient quantity to detract from the value of the barytes, and, when ground, it forms a powder almost as white as the latter.

NEWFOUNDLAND.

The first mention of barytes in the shipping returns of this colony was for the year 1902, when 315 tons, valued at $2.00 per ton, were exported to the United States.

NEW BRUNSWICK.

Dr. Bailey *notes the occurrence of barytes in the Laurentian limestones on Frye island and Grand Manan, also near the summit of the Lower Carboniferous at Gouldville, associated with some galena. From this locality a considerable quantity was once shipped. Barytes has been reported near Memramcook by Daniels in 1878.

NOVA SCOTIA.

Probably the earliest reference to barytes in the Lower Provinces is in the "Geology of Nova Scotia" by Jackson and Alger, 1832, p. 79, where mention is made of it in geodes of the hematite of the East river of Pictou. In this locality, when the mining of limonite was actively prosecuted by the Nova Scotia Steel and Iron Co. in the nineties, the association of barytes in the deposit was of frequent occurrence and proved objectionable in the blast furnace. It was distributed in such detached crystal groups or was so disseminated through the iron ore that it was not profitable to clean it sufficiently to render it marketable.

Sir J. W. Dawson† mentions a deposit of barytes quarried on the banks of the Stewiacke. He adds that the deposit appears to be exhausted in so far as it can be reached by ordinary quarrying operations. He also mentions barytes as occurring in small crystals lining fissures, and in compact veins of ankerite in the Great Village river, as also in veins

*Geol. Sur. Report for 1897, Pt. M.
†Acadian Geology, 1855.

in the banks of the East river of Five Islands, which veins he considered to be a continuation of the great iron veins of Londonderry, and from whence large quantities of barytes have been exported to the United States.

The presence of barytes in the Carboniferous rocks of Nova Scotia, in veins and pockets at the contact of formations of distinctly different horizons, has been long known. It is found both compact and crystalline, also in well defined crystals lining cavities and coating minerals already deposited. In this crystalline form it is seen at Bridgeville in Pictou county in the limonite mines already referred to on the contact of the Lower Carboniferous with Silurian strata, where it is deposited, but not in quantities, associated with the ores of manganese, spathic and other iron ores of the East River district. In other localities in Nova Scotia the mineralized zone at the contact of the Sub-Carboniferous with lower formations has been found to carry barytes scattered and in patches. The irregularity of the deposits has entailed an amount of deadwork out of proportion to the quantity of mineral obtained. Operations have not, hitherto, been continuous. The most extensive deposits of this character opened up were at Five islands and on the north side of the Stewiacke valley to the east of Brookfield station, where the contact is of Devonian and Lower Carboniferous. (*See* Geological Survey maps.)

In distinct veins barytes is known to occur in quantity on the Gulf shore of Cape Breton, north of Cheticamp island, also inland about Lake Ainslie. In both of these localities the country rocks are of the oldest in the province, and lie in, or in the neighbourhood of, eruptives. They are classed as Pre-Cambrian.

In Inverness county near Port Hood, Brook-village and in the Judique Chapel brook near John Cameron's, there is a deposit in veins in a fine conglomerate.* At Finlay point, near Mabou Coal Mines, barytes in some quantity occurs along the line of contact of the Carboniferous rocks with felsite. It also occurs in Richmond county near Loch Lomond and, in Devonian strata, near McMillan point on the Strait of Canso†; at Springhill, in millstone grit, on the south branch of Black brook, in veins a few inches wide; at Greenville; on the west arm of the river Avon; on the East mountain of Onslow; at Frenchmans Barn, Arisaig; and at Hodson, five miles from River John it occurs in small veins and lenses mixed with calcspar, in grey sandstones of the Upper Carboniferous or Permian rocks. One belt is about seven feet wide.

*Geol. Sur. of Can., 1882-84, Pt. H, p. 69.
†Geol. Sur. of Can., 1879-80, Pt. F, p. 125.

First opened in the seventies when there was a brisk demand for barytes, some 480 tons were shipped and valued at $5 per ton. The locality was again prospected in 1900. In the same rocks in many of the branches of River John, above John McKay's, near Mr. Morrison's, on Nabiscump brook, near Peter Gratto's mill, near McBean's house, and at Welsford between the mills and the shop, barytes occurs. In one conglomerate the pebbles are held together by barytes mixed with a white crystalline calcspar.

Its association with ores of iron at Bridgeville has been mentioned. At the Acadia iron mines barytes is associated in small quantities with specular ore and ankerite; and it is common with the iron ores of Clifton and at the mouth of the Shubenacadie river. At the latter place white and reddish crystals, a quarter of an inch long, line the walls of cavities in the ore, and in some places are curiously coated over with a velvety oxide of iron, which gives them a rounded outline.*

Barytes Mining.—Among the earliest reported workings of barytes in Nova Scotia were the operations of Mr. Sewell of Bath, Maine, about thirty years ago. He opened the Eureka mine, Colchester county, by an adit driven from Bass river. On what appeared to be an extension of the same deposit on the top of the hill the Dolphin mine was opened, and, at a still later date, (about the year 1896), J. Prendergast, a prospector well known in the seventies, explored part of the ground for Mr. T. R. Gue. The deposit is reported to be at the contact of two series of rocks and is said to be too irregular in deposition for profitable operations. The barytes occur in places highly crystallized and, in parts, coated with large crystals of calcite. Some of the crystals of barytes were dotted with inclusions of pyrites, and the crystalline masses were sometimes stained a reddish tint which detracted from the value of the ore.

The Eureka mine was near the village of Five Islands, and the mineral contents of the deposit were found generally well crystallized. These were chalcopyrite and specular iron ore, masses of tabular crystals of barytes, generally with inclusions, and barytes in pockets encrusted in cavities by dog-tooth spar. Large aggregates of both calcite and barytes were obtained. In all some 3,000 tons were mined, but the deposits were found too irregular for profitable mining. The mine was shut down for many years but eventually the deposits were re-examined, and further explorations in the neighbourhood were made costing nearly $2,000. These explorations extended from the East river, over the hill

*Geol. of Can., 1873-74, p. 220

for about a mile and a half to the adjoining ravine, and confirmed the conclusions of the previous workers. The deposit is spoken of as blanketing the hill only a few feet below the surface, and rarely exceeds fifteen inches in thickness: the thickest portion uncovered in the latter openings was a lense or kidney nearly four feet thick. The quality of the mineral is described as excellent.*

Mr. H. Fletcher mentions white and reddish barytes being quarried from numerous irregular veins, sometimes three feet wide, or beautiful crystalline masses in the slates on the steep banks of the East and Bass rivers of Five Islands. Elsewhere the reports of the Survey note that this deposit of barytes is two miles up Bass river. Eight hundred tons of ore were shipped to the United States in 1874-75, with a total shipment to 1885 of over 3,000 tons, valued at $10 per ton. The ground material was stated to be worth $30 per ton. Part of the output was used in the paint mill of the Dolphin Manufacturing Co. of St. Catharines, Ont. The ore in part occurs in rocks which were at one time assumed to be Cambro-Silurian, but which are now regarded by Mr. Fletcher as Devonian at a contact with Lower Carboniferous.

The Stewiacke deposit lies about six miles east of Brookfield station, or a mile west of Bill Putnam brook, and half a mile north of the river. Professor How† describes the operations previous to 1868. The ore was in three veins, averaging eighteen inches in thickness, perfectly free from pyrites and other metallic minerals, but containing traces of graphite. Mr. H. Fletcher says that the veins seem to traverse irregularly a grey argillaceous limestone, which is also cut by small veins of bright red calcspar. At Upper Brookfield in the neighbourhood of the iron mine, two to three miles from the railway station, a pocket of mixed limonite and barytes was said by Professor How* to be fifteen feet wide.

CAPE BRETON.

The workable vein deposits of the island of Cape Breton centre round Lake Ainslie and the shore section of North Cheticamp.

THE DISTRICT OF LAKE AINSLIE.

Topography.—Lake Ainslie, roughly triangular, is the largest sheet of fresh water in Cape Breton, and its attractive scenery vies with that of the Bras d'Or. It is fringed by fine farms hedged in by high hills. The northeast corner of the lake forms at Outlet the headwaters of the south-

*Geol. Sur. of Can., 1882-84, Pt. L, p. 23.
†Mineralogy of Nova Scotia.

west branch of the Margaree river, a well known fishing stream. Its northwest angle, Loch Ban, is touched by the Inverness and Richmond railway at Strathlorne station, and from Lakehead, its southern apex Ainslie Glen, with the Mullach on its left, descends to Whycocomagh on the Bras d'Or. The surface of the lake, at high water, is about 155 feet above sea level; its depths are shallow varying from twenty-four feet, with a muddy bottom in the centre, to a maximum depth of fifty-seven feet off Sand point where it narrows towards its southern end, and the ancient glacier, crowded between high hills, has deepened its bed. Some thirty years ago, when it was proposed to drain the lake through the glacial drifts that dam back its waters at Strathlorne, systematic soundings giving the above results were made by Lauchlin McMillan who tells me that there is shallow water off the northern side and another shallow off the east side of the lake to Outlet, with deeper water nearer the shore. This depression may be assumed the line of drainage before the final damming up of the lake waters. The foreshore of the lake is generally stony, with well worn coarse pebbles so packed together as to present a paved appearance, while the larger boulders have been seized by the ice and thrust against the banks, for even in this lake the ice-shoves in the spring have great power and make heaps many feet in height. During open water strong winds cause currents and great waves to assort the sands and smaller stones, and form with them beaches in the coves. These collections are most noticeable where the streams of pre-glacial times flowed at a level lower than their present beds and originated the coves, which, since the formation of the lake, have been the collecting ground for recent deposits, the accumulation of wash from the land and sand from the abrasion of the grit-stones in the rocky beds of the watercourses pouring down the steep hillsides, the beach deposits being a measure, as it were, of the time that has passed since the glacial period deposited the mounds of mixed earth and stone along the lake-edge and the outlets of the gorges. At McLean point and onward to Lakehead are mounds with steep sides, clothed with brush to the water's edge, and partly faced by boulders; they are now subject to little or no wave action, even at the point the most exposed to the strong sweep of the winds across the lake from the northwest. The coves which the pre-glacial stage left at Glenmore, East Lake Ainslie, Trout river and about McLean point are now partly silted up with the sands which the lake waves have sorted out and cast ashore. The characteristic red brick clays of the glacial period seem to be absent from this locality.

Geological Structure.—References will be found in the opening pages of Mr. H. Fletcher's report on the Geology of northern Cape Breton*

*Geol. Sur. of Can., 1882-84, Pt. H; map sheets 13, 14 and 15.

to the basal rocks, classed as Pre-Cambrian, and to those of them which form the steep west front of the plateau of high ground lying between Lake Ainslie and Middle river. . The course taken by the broad ridge is approximately parallel with the west coast of the island and was seemingly determined by long past orogenetic pressures. Its surface deeply eroded prior to Carboniferous times, the inequalities became occupied by massive beds of coarse grit and, together with Pre-Cambrian protrusions, were reduced by sub-aerial agencies to the approximate peneplane of later periods.

References are also made to the igneous rocks, the felsites and traps which are now shown to have an important relation to the barytes deposits to be considered in this bulletin.

No trace remains in this region of any sedimentaries of intermediate ages, Cambrian, Silurian or Devonian. Of members of the Lower Carboniferous, Mr. Fletcher places the coarse grits occupying the higher ground with the Carboniferous conglomerate and classifies the other succeeding members of the series with the Carboniferous limestone. These softer beds of red marls, shales, fine-grained sandstones, gypsum and dark limestones suffering greater denudation, give direction to the glens and river-courses and determined the lake site. Small patches of grey measures on the south shore of the lake, near the chapel, and again where associated with some bituminous shales on the Margaree river, two miles below Outlet, are probably millstone grit. Of the higher members of the Carboniferous system that carry coal seams in places near the shore no repetition seems to have been left inland in the shelter of the monoclinal and anticlinal folds.

The series of Lower Carboniferous rocks of this locality has its lowest members, reddish shales and mottled clay beds, resting on igneous rocks. These are not always present, and in such cases the contact bed is apt to be an impure dark limestone which outcrops at many places along the hill front. This limestone is in turn overlaid by argillaceous shales and bedded sandstones. No gypsum has been exposed on the east side of the lake, but depressions at several spots in the surface, similar to the so-called "plaster pits," suggest its presence. On the west side of the lake gypsum is to be seen.

On the higher lands to the east the rocks capping large areas are coarse grey grits which supplied much of the loose stones and boulders sprinkled with granite on the surface. The grits are classed as Carboniferous conglomerate. The valley of Glenmore, which is occupied by Lower Carboniferous rocks, would appear to have been eroded before Carboni-

ferous times to a lower level than that at which the streams flow to-day, while the ravine of the Gairloch road marks an erosion subsequent to the period of the Lower Carboniferous. At many places exposed along the contact there is much disturbance of the newer strata with high dips and, possibly, some overturns.

The Discovery of Barytes.—In this district, previous to 1890, the presence of a white rock, heavier than quartz, was well known to the inhabitants on the east side of the lake. At the foot of some of the hills were blocks of it far too large to move and measuring up to eight feet in length. Those of smaller size were gathered up and cast on the stone heaps or thrown on the roadside out of the way of the plough. The smaller stones and pebbles of the same rock became exposed on some hauling-roads over the lower slopes; the unusual weight of the rock attracted attention and induced the youth of the neighbourhood to select boulders of suitable size to try their skill at putting the stone. but it was not until about 1890 that the name and value of the rock became known.

The barytes-bearing district of the lake lies along the flank of the high land on the east side from Outlet, to the mouth of Trout river near where the lake narrows at McLean point.

Within this field, for a distance of some six miles, indications of barytes have been detected at many places. The indications nearest to Outlet have been noticed on the brook flowing behind the house of Edward Campbell, but no exposure of a deposit has yet been made. The next appearance is half a mile westward by the side of a wood road on the rear lands of Farquhar McKinnon, at a height of 600 feet, where some ten tons were removed from an outcrop which has a bearing S. 60° W. The rock here is a mottled grey felsite; between it and the main road are dikes of very dark trap and from it the old road to Outlet passes down over a strip of red shales which underlie grey sandstones of the Lower Carboniferous series that fringe the shore of the lake. Crossing Cobb brook in a westerly direction a few scattered boulders have been seen on the lands of Allan McLean and J. McDougall. On the grant to Lauchlin McMillan, now divided between McMillan and Thomas Campbell, occur the important deposits now being developed by S. M. Brookfield and his associates of Halifax under the management of H. H. Harrison, to whom acknowledgments are due for much assistance and information respecting this field.

The mining operations here are on the cleared hill rising from the right bank of Mill brook, on which the Geological Survey map marks a grist mill. Beyond the left bank of this small stream, on the property of J. J.

McLean, some surface boulders may be seen, but on the next three adjoining farms along the lake-front none as yet have been observed, or, at least, reported. Onwards toward Trout river barytes drift has been found in varied abundance and with wide veins standing prominently above the surface of the hill at Norman Johnston's, where Messrs. Henderson and Potts, paint manufacturers of Halifax, have been mining for several years. On the adjoining grant to Murdoch McDougall, just across the Gairloch Mountain road, a vein has been opened. On the next three properties belonging to D. D. McKenzie, Donald McKay and L. R. McKay, numerous large boulders are exposed, but their source has not been determined.

On the holding of the last named, occupying the right bank of Trout river, indications of barytes cease on the east side of the lake. Beyond the river the rocks in places are thickly covered by glacial drift, and the only exposures on the lake side are Lower Carboniferous beds which continue to occupy the lake front and the high ground to Lakehead.

MINING OPERATIONS AT LAKE AINSLIE.*

When it was recognized that the heavy, white boulders strewn about the fields were not quartz but barytes which possessed a market value, operations were begun on the holding of Norman Johnston, 1,000 paces from the lake. There the white rock stood boldly out above the surface of the hill beside the Gairloch Mountain road as it enters the ravine to wind up the rising ground to the level of the plateau.

This float of barytes is supposed to indicate the presence of some seven veins, three of which have been partly exploited. The strike of the veins is N. 80° E. to S. 75° E. and is across the axis of the felsite hill and the north fork of the ravine. Boulders of barytes are in the soil on the left bank of this fork and nearly up to an exposure of a dike of trap running N. and S. which is supposed to cut off any extension of the veins to the eastward. Beyond the dike are coarse grits of the Lower Carboniferous. In the other direction the dark limestones and sandstone beds and shales of the Carboniferous limestone have been exposed overlying the western extension of barytes veins.

Operations on the main vein, which is about eight feet wide, consisted of an upper and lower drift for some 200 feet westward, at which distance a vertical cross vein or branch came in from the northward and yielded barytes from nine to twenty feet in width for a length of 125 feet. The extent of these north and south leaders and the number of them that are

**See* Addendum, p. 43.

workable have not been determined. From the openings made an opinion has been formed that they do not carry their great width continuously in depth.

Towards the top of Johnston hill a trench has been dug along an outcrop east and west across the hill and has exposed from eighteen inches to three feet of barytes dipping 80° northward; float of barytes 125 paces north of this trench indicates another vein which would extend across the ravine to the eastward.

No mining was prosecuted in 1904, there being a supply on the dump from the previous year's operations. The mineral ore is carted by the way of Ainslie glen twelve miles to Whycocomagh for shipment, at a cost of two dollars per ton. Messrs. Henderson and Potts, the mine operators, report having extracted in all some 3,574 tons to the end of 1904 since they began work in 1890.

West of Gairloch Mountain road the only openings made were at 180 paces from the road, where four feet of barytes outcropped on the hill side, course N. 85° E. A drift some twenty feet lower found the vein pinched but to what extent was not proved. From this point the Pre-Cambrian continues nearly to Trout river, but the reddish felsite is not seen in the river ravine or any farther to the westward. If any extension exists it is hidden under heavy surface cover which does not show any float of barytes. The surface pebbles are chiefly composed of the coarse grit which occupies so much of the high land. The last boulder of barytes to be seen is on a knoll behind L. R. McKay's house, some 650 paces from the highway bridge at the mouth of Trout river. The exposure looks like an outcrop and is not less than eight feet wide, but it has not been fully uncovered. Other boulders of large size lie nearby and, in the soil sloping northward, are many smaller ones. They range along the lower slope through the adjoining farms close behind the homesteads of D. McKay and Mrs. McMillan.

Returning northward along the Pre-Cambrian range no trace of exploration is seen until Mill brook and Burnt hill are reached. Here are situated the latest developments, conducted by the Eastern Milling Company, under Mr. H. H. Harrison. These operations are carried on in veins which trend parallel to the north face of Burnt hill, and, with a southerly dip, approximate the average course of the Gairloch Mountain road veins.

Operations have been pursued at three points, viz.:—To the east (on the land of Lauchlin McMillan) by an open cut near the crest of the

hill. In the centre, at a somewhat lower level and parallel, 200 feet northward (on the John McDougall property); and to the west on the steep face of the hill on the Campbell vein. No openings have been made on the south slope of the hill to the brook. Eastward, prospecting stopped short at a point 900 feet along the series of veins, where the water courses attain high ground and lose their rapid flow, but, seemingly, the barytes-bearing rock, felsite, extends much farther in that direction and probably carries mineral with it.

The McMillan open cut extends some 170 feet and, where worked, shows a width of from eight to sixteen feet of ore. The hanging wall is well defined; the foot wall is somewhat shattered and the disturbed blocks of rock are cemented with barytes.

On the McDougall vein openings have been made 125 feet east and forty feet west of a drift to it from the north slope of the hill, and several parallel stringers of irregular width were cut. At a depth of thirty feet the vein opened out below a pinch and there shows a width increasing to eight feet at one part.

The Campbell vein has been worked by five drifts on the western face of the hill; the lowest, at the base of the hill and near the engine house, is driven in on the vein 175 feet, the second sixty feet, the third forty feet, the fourth thirty feet and the highest (250 feet above the lowest level) fifteen feet. They all show over seven feet and even up to fourteen feet of vein, with a grey clay gouge on the foot wall.

The foot hill extending westward under the deposits of the Carboniferous limestone doubtless also carries, in that direction and in depth, extensions of the barytes veins.

A tramway round the shoulder of the hill brings the ore from the open cut to a shoot, at the base of which, on the west front of the hill, a track runs to the lake and to a steam barge for conveyance eight miles across the lake to a special siding near Strathlorne station on the Inverness and Richmond railway. From these veins a great deal of float has been carried down hill towards the north; only one solitary boulder of barytes was to be seen on the crest of the hill about a hundred yards to the southward of the strike of the veins, in which direction no discoveries of ore have been made. But across Mill brook, in the ravine, at a lower level, some barytes boulders occur in the soil. The northerly drift of the float has carried barytes boulders half a mile on to rising ground by the roadside where no rocks in place are visible and where the beds underlying are assumed, from their surroundings, to be Carbonifer-

ous limestone. On Burnt hill, as well as on any exposures of rock surface along the hill front of East Lake Ainslie, there is no glacial polishing or grooving. The only indication of moving ice coating was seen on a sandstone bed, without direction, high up on the hillside east of Cobb brook.

McMillan's open cut on the hill-top has shown no ice-polished surfaces, but the superficial rock and the outcropping of the veins are shattered by long exposure to subaerial agencies, the only evidence of heavy frost being a layer of angular fragments of rock, washed clear of clay and small stones, lying on top of the disturbed and fractured rocks and underlying the mixed soil and stones of the surface.

Analysis of Lake Ainslie barytes by F. H. Mason, F.C.S., &c.:—

Moisture lost at 100° C	.05
Sulphate of baryta	94.20
Sulphate of lime	0.02
Carbonate of lime	4.44
Silica	0.05
Ferric oxide	0.11
Alumina	0.04
Magnesia	Trace.
Loss on ignition	1.01
	99·92

Vein Associates.—In the principal barytes veins there may occasionally be seen both calcite and fluor-spar in small quantities; at McDougall's opening on Burnt hill the fluor-spar is apt to be more aggregated in the narrow leaders than in the main deposit, in which it appears as small crystalline centres of a light green colour, where the vein matter is not compact but is in part vesicular. The semi-crystalline cavities near the surface of the veins are often found to be dusted over with a black powder which examination has shown to be wad, impure manganese oxide, soluble in acids.

Petroleum.—But in other parts of the veins there are spots where acid fails to clean off the matter, which there discolours the barytes and coats the cavities and their imperfectly formed crystal faces. This substance was pointed out to the operators and shown to be inspissated petroleum, which can be got rid of by heat. The quantity seen was small and quite local, but the presence of two such dissimilar substances requiring different treatment is worthy of note so that care may be taken in the mining and any sorting deemed expedient may be then made.

When the search for petroleum was made on the lake shore as described by Mr. Fletcher,* there was one hole put down on the north side of the Gairloch Mountain road half a mile from the lake, close to the barytes mines of Henderson and Potts, and sixty paces short of a strong spring of water having a metallic taste. At fifteen feet the borehole passed through the surface soil and entered a white rock in which it continued, it is said, to a depth of 200 feet. The borings whitened the bed of the brook and formed a layer on the beach of the lake but were not recognized as barytes. The mineral was supposed, at the time, to be plaster.

It is unfortunate that no complete records have been published of the numerous boreholes around the lake which pierced Lower Carboniferous measures in search of oil, and that no one seems to know the character of the rocks passed through or at what depths changes were met.

Springs and their deposits.—Numerous springs of water issue at the foot of the range near the contact of the Carboniferous limestone beds and the Pre-Cambrian. Several are of great volume and two have supplied power for milling purposes. Some have a metallic taste, and some have doubtless been the source of the deposits of red and yellow ochres at the base of Burnt hill and other places. These have found a local use. Elsewhere the swamps of other springs have been blackened by the deposition of an impure oxide of manganese. These latter have not taken the fancy of the mineral prospector as they have in the neighbouring province of New Brunswick, where rights of search for manganese in bogs no more extensive than those in Cape Breton have been a source of much revenue to the Government.

The deposits of barytes at Lake Ainslie appear to furnish an exception to the previous experience of the provincial miners which indicated the occurrence of barytes only in irregular pockets and not as a component of persistent vein matter. The exception can only be spoken of provisionally, as the workings on the veins are not sufficiently extensive to enable one to speak with assurance.

It will further be noticed that the more productive veins form a group of their own, all approximately parallel to one another in a direction quite oblique to the course of the hill range in which they occur, and to the mountain foldings which established the highlands of Cape Breton.

Veins other than those having a general course about N. 75° E., and oblique to the hill range, have been found carrying barytes, but the ex-

*Geol. Sur. of Can., Rep. for 1882–84, Pt. H., pp. 43, 90. Summy. Rep. for 1897, p. 102.

perience hitherto gained in the openings on veins affords greater inducement to the prospector and operator to search in the particular district for mineral veins having a bearing true northeast and southwest.

In the Report of the Geological Survey of Canada, 1882-4, the igneous rocks of this field are classed as felsites, those that carry the veins of barytes being of a banded variety or granular and highly quartzitic.

It would further appear that there may be a bond between this particular class of felsite and the barytes as vein matter in the fractures which resulted from movements or strains oblique to the general folding of the country. The frequency of the repetitions of the veins in parallel cannot be wholly accidental; at any rate it is sufficient to make it marked and to warrant, in further searches, a preference being given to protrusions of the same kind of rock in this hill country of Cape Breton.

The greater quantities of mineral found in veins having the reddish felsite for their country rock has already suggested a preference for localities where the conditions appear similar; prospectors of the district about Lake Ainslie have been encouraged, by the present activity in this branch of mining, to extend their explorations beyond the escarpment facing the lake on its eastern side. They are now ready to follow to their source the shoad-stones dotting the surface soil at other places, on the Middle river, five miles to the eastward, and again across the lake on the south slope of the igneous mass at Brookville and immediately to the west of Lakehead, where barytes float is reported.

The barytes-bearing series of rocks are more widespread than appears on the surface, for, not only are the Pre-Cambrian deeply covered in places by drift which retards prospecting, but they are evidently overlaid along the hill flanks by rocks of later deposition. Beds of Lower Carboniferous near the contact have been proved to be, in places, quite shallow. The surface drift is of variable thickness, and bore-holes have proved it to be, in places, as much as forty feet. It forms the eastern shore of the lake, except where rocks occasionally protrude through it. The holes bored for oil along the lake side passed through a great thickness of bedded deposits, indicating a continuation of the steep front to the older rocks underlying them. This view also applies to the shelf of felsite which carries with it barytes veins at a level nearer that of the lake. The shelf appears to present a steep front to the submerged north and from its edge the covering of Carboniferous measures has been eroded, exposing the shoulder and its veins, from whence, doubtless, came the loose, overlying boulders.

It may be surmised that the same range of rocks continues the shoulder west of the Trout River ravine although it is hidden from sight by a superficial covering of soil and Carboniferous beds, under which it may extend as far as the low ground to McLean point. There is nothing to justify a supposition that the prolongation westward of the Pre-Cambrian felsite is cut off at Trout river, beyond the fact that it has been reduced to a lower level and put out of sight by the pre-glacial erosion of the stream.

THE DISTRICT OF NORTH CHETICAMP.

This field has, of late, been second in importance to that of Lake Ainslie and, although the presence of barytes was long known, it was not until 1900 that any workings were attempted. They have been made in the section of country lying along the shore between Cape Rouge and Presqu'ile.* In his Mineralogy of Nova Scotia, Professor How mentions on the authority of Mr. Barnes the occurrence of barytes boulders fourteen miles northeast of Cheticamp. This doubtless refers to the neighbourhood of the Lazaar river (Corney brook) some eight miles eastward of the more modern settlement, Eastern Harbour, the farthest point in that direction at which barytes float has been seen, and which is one of the places lately opened. The schists in which the barytes deposits occur are spoken of by Mr. H. Fletcher as equivalent to the Louisburg shales elsewhere described by him.

The barytes bearing schists have a general dip to the north at a high angle, the planes of schistosity dipping 60° to the northwest. They are very fissile and much jointed, readily furnishing slabs that are often six-sided and rather suggestive of enlarged cleavages of mica. Their characteristics have been more particularly described by Mr. M. V. Grandin, who has for many years been an enthusiastic observer of the geology of this field. Mr. Grandin permits me to extract the following from his unpublished notes, a description of the topography of the field, with some of his views on the lithological characteristics of its schists and faulting:—

"*The veins* traversing the schists in this locality carry besides barytes, "quartz, calcite, and fluorite with a later deposition of hematite in the "joint planes; the quartz and calcite are in masses at times several feet "in width and the fluorite is more abundant than in other sections of "the province so far explored.

"The veins of this field have a course generally parallel and a sinuous "bearing nearly north and south observed in some cases to be on an

*Geol. Sur. of Can., Rep. for 1882-84, Part H, pp. 21 and 95, also map-sheet No. 6.

"average N. 4° W., with a heading nearly vertical and also sinuous. The "sinuosity of these veins is associated with a lateral displacement and "has left the contents somewhat in the form of lenses, a swelling out "occurring when the deflection of the course is in one direction and a "pinching or thinning of the vein following an undulation to the other "side of the general bearing. Changes in the hade of the lower workings "were observed to be attended by a similar variation in the width of "the veins in depth, and these alternations were sufficiently numerous "to warrant the miners anticipating the thickness of the veins ahead of "them, but operations have not yet been sufficiently extensive to deter- "mine the probable frequency and extent of the lenses of vein matter.

"Operations on the lands of Amedée Comus at Corney brook have "opened a vein from the upper part of the shore cliff inwards for a dis- "tance of over 100 feet and show it to vary from ten inches to four feet "in thickness, expanding, in one place, to a width of over eight feet. "The vein passes close to the house of E. Comus but has not been fol- "lowed southward beyond a small water-course which has deeply eroded "into the schists where it crosses. On the shore below the house the "downward extension of the vein is hidden, but a series of parallel veins "bearing about northeast and southwest under the water is easily seen, "and they are apparently a distinct deposit. From the opening made "some 950 tons of barytes were shipped, but operations were hampered "by a want of shelter for vessels, the coast east of Eastern harbour lying "exposed to the full force of all northerly winds.

"A second vein was opened near the west side of Trout brook, but "the workings were confined to a lense of barytes also having a course "N. 10° W. by the side of the shore road, crossing near the brook's mouth. "Here the schist is sericitic, and dips north at about 30°.

"A third opening on a vein of barytes was made nearer Presqu'ile "on the land of Eusebe Poirier, about 400 feet to the south of his house, "at an elevation of 350 feet above sea level, and some 500 yards from "the shore. At the lower opening, where the vein was first attacked, "it headed E. $<$ 30° but as the cut extended south on the vein it became "practically vertical.

"A drift along the vein for 120 feet proved a width of from three to "six feet, and other openings on the hillside showed the vein to continue "for a like distance farther to the south. At the southern extremity of "the cut, along the vein, a narrow cavity, that extended downwards, "was exposed, but its depth and extent were not improved; possibly "this cavity may have been caused by the removal of calcite from the

"vein. At the 'face' there was also exposed a small pocket of fluorite "deeply eroded, an unusual condition for fluorite and a suggestion, per- "haps, of vast age or of the effects of emanations of volcanic character. "About 200 yards west, at a lower level, less extensive openings, off the "old road, have supplied barytes, fluorite and calcite; of the barytes "about 700 tons have been exported within the past two years.

"*Topography of North Cheticamp.*—The barytes-bearing schists of "Cheticamp occupy part of a narrow tract of country extending along "the shore in a northeasterly direction from Jerome mountain to the "mouth of Corney brook. Small as this tract is, from the great variety "of its geological structure it contains a remarkable diversity of scenery, "and the visitor, whether he be artist, tourist, geologist or miner, cannot "fail to find much to instruct, interest and admire.

"At the southwest extremity of this tract, four and a half miles in a "northeasterly direction from the village of Eastern Harbour, stands "Jerome mountain, a bold promontory of the grand escarpment of the "great plateau of northern Cape Breton, towering a thousand feet above "sea-level and presenting, with its craggy and castellated cliffs and "majestic talus slopes, one of the most salient landmarks of Cheticamp. "On a bright day the vivid and strongly contrasted colours of its red "granites, black and purple basaltic dikes, variegated sedimentaries set "in sparkling beaches on deep blue sea, make a most brilliant picture. "In clear weather its summit, on all sides, commands the surrounding "country: from the brow of its southern precipices one looks down on "the dark mountain glen of Jerome brook, its floor littered with huge "fragments from the impending cliffs; to the southwest lies, spread out "like a map, the fertile and undulating plain of Cheticamp, dotted with "many homesteads, the river meandering through its flood-plain to the "sea; in the distance Eastern Harbour and Cheticamp island complete "the view. To the south and east, as far as the eye can reach, stretches "the great plateau with its sea-wall trenched by labyrinths of ravines and "gorges; to the north, at the base of the mountain, and separated from "it by a pretty, oval lake, rises Presqu'île, its verdant ridges and bright "ribbon-like beach linking it to the mainland beyond which spread the "blue waters of the Gulf of St. Lawrence, out of which, in clear weather, "the Magdalen islands loom against the northern sky. To the north- "east is overlooked the whole extent of the barytes range, rising at first "in lofty mural cliffs from the sea and then by steep craggy slopes to the "level of the plateau. In the distance Cape Rouge elevates its ruddy "summit, and between lie the high V-shaped gorges, excavated by Corney "and Trout brooks and their feeders in their descent from the plateau. "At the mouth of the Trout, fifty feet above the beach, stretches a long

"level terrace, suggestive of some ancient shore-line formed during a "period of rest when this land was emerging from the sea.

"The main road through this tract follows the shore trend, winding "around steep slopes and edges of dizzy cliffs until it terminates at the "base of Cape Rouge mountain; from it many striking views can be "obtained and all the known barytes deposits can be easily seen or "reached.

"The barytes deposits of Cheticamp, so far located, lie within a belt "of Pre-Cambrian schists, which extends an undetermined distance into "the interior, but is bounded on the southwest by the granites and traps "of Jerome mountain, on the northeast by the granites and other igneous "rocks of Corney brook, and on the north by the Gulf of St. Lawrence "and two small patches of Carboniferous rocks, one at Presqu'île and "the other at Trout brook.

"*Lithological Characteristics of the Schists.*—Although many of the "Cheticamp schists are probably altered igneous rocks, the schists of "this section appear to have been originally shales and argillaceous sand-"stones. At the extreme eastern end of the belt they are less quartzose "but more fissile than in the middle and at the western end. The latter "are more heavily bedded, splitting up into slabs varying from three-"quarters of an inch to four inches thick or more, and no doubt represent "sandstones, while the former readily split up into laminæ of about an "eighth of an inch thick or less, and were probably originally shales. "The schists of this section may be classed as hydromica or sericitic "schists. They are usually a greyish green colour, soft and somewhat "greasy to the touch, with a silvery lustre on the planes of foliation due "to thin laminæ of mica deposited along those planes.

Foliation,—"Between the Cape Rouge barytes deposit and the granite "to the east of it, the schists are more curved and crumpled and the folia-"tion is more lenticular than is the case with the schists to the west, in "which the foliation is usually flat, parallel and evidently coincident with "the bedding planes which are often indicated by layers of slightly differ-"ent colour.

Metamorphism.—"From the fact that the Carboniferous conglomerates, "which in places overlie the schists, frequently contain fragments of "the latter it would seem proved that the metamorphism of the schists "preceded the deposition of the conglomerates.

Joints.—"A very complex system of jointing has been developed in these " schists with two series of master joints, a north and south and a north- "east and southwest. It is they that have determined the peculiar shape "of the three, four and six-sided slabs into which the schists break up. "The intersection of the more or less vertical joint planes encloses spaces "which are either triangles, rhomboids or hexagons. These planes, "being again intersected at about right angles by the planes of foliation, "cause the schists, when exposed to weathering agencies, to break up "into many sided slabs.

Folds.—"A comparison of the structure of the schists of this section with "that of the* L'Abime schists (South Cheticamp) makes it appear that "they owe their origin to deposits of different kinds. The schists of this "section are situated on an anticlinal or monoclinal fold and are in a "state of tension, whereas the L'Abime schists occur between uplifts "of granitic rocks and are in a state of compression. In the former, "then, we may expect normal faults and deposits of the fissure vein type "to predominate and in the latter reverse faults and deposits of the com- "pression vein type. And such appears to be the case; the axis of the "fold in this section runs approximately east and west, but it is also "occasionally traversed by small cross-folds whose axes pitch north. "Where these cross-folds occur the schists have been compressed and "compression veins may be expected. A deposit of such a nature occurs "on Trout brook in close proximity to the axis of a cross-fold.

"*Faults and Mineral Veins.*—In the uplifting of the granitic platform "at least two series of faults were developed in the schists, one running "in sinuous lines approximately north and south and the other northeast "and southwest parallel with some of the main jointing. The north and "south series are dip faults, whilst the northeast and southwest series "are sometimes oblique and sometimes strike faults. The fault fissures, " when not occupied by igneous rocks, are now usually found filled with "either barytes, calcite, quartz or fluorite, or mixtures of these gangue "minerals."

Calcite veins.—Of these, the two largest known have a north and south strike. One, exposed in the cliffs of Presqu'ile lake and in openings on the flanks of Pousnette mountain, in close proximity to parallel trap dikes, carries in places considerable quantities of copper pyrites. The horizontal and vertical pinches and swells, so common to fissure veins in general and characteristic of those of this section, are probably due to horizontal and vertical displacements which have brought pro-

*Faribault brook of Geol. Surv. map-sheets 6 and 9; Summy. Rep. for 1898, p. 148.

jections in the fissure walls opposite projections, and depressions opposite depressions. The copper ore is very unevenly disseminated through the gangue, small nodules of almost microscopic size prevailing in some parts, while in others masses weighing up to seventy pounds occupy almost the entire width of the vein. In some places the vein is perfectly barren of ore, being occupied entirely by compact crystalline calcspar. In other places the ore has evidently been leached out, leaving cavities which have been subsequently filled with wad. This vein varies from two to four feet in thickness.

The next calcspar vein of importance is one averaging about five feet in thickness and intersecting a sheet or dike of trap at Jerome mountain. The vein strikes north and south and the dike N.N.W. and S.S.E. They both hade towards the east, the former at 20°, and the latter at 60°. This vein also carries copper pyrites associated with secondary ores, such as red oxide and green carbonate of copper, but the ores are apparently confined to the point of intersection, the openings on it, on either side of the dike, showing the vein to be barren. The ores are found in layers and masses along the walls of the dike at their contact with the granite, in lesser quantities disseminated through the dike and also in the granite sometimes at a distance of two to three feet away from the dike. The intensity of the shearing movements to which the dike has been subjected is shown by the development of cleavage planes parallel to its walls, which has given the trap a somewhat schistose appearance.

Fluorite Veins.—Of these only one which can be said to be mainly fluorite has yet been observed. This vein is displayed in an opening at the base of the cliffs at Presqu'île beach. It occupies the north side of a trough piece of a trough fault running northeast and southwest, which is evidently connected with a powerful fault which traverses the country for miles parallel to the shore line. The thickness of this vein is not easy to determine owing to the shattered condition of the schists, but it was evidently very variable, the maximum thickness probably not exceeding fifteen inches. In places the vein carries a fair quantity of copper pyrites associated with ochreous hematite. On the south side of the trough piece the gangue mineral is quartz.

Fluorite.—Inquiry is often made for this mineral, for which reason reference is made to its occurrence in this locality, in much greater quantity than is known elsewhere in the province. There is, however, no reason to expect that it may exist in masses sufficiently large to warrant independent working; possibly as an associate mineral, it may justify separa-

tion and collection, should mining operations be again conducted in this neighbourhood.

Other localities where fluorite has been detected in minute quantities are noted by Mr. Fletcher in his reports.

Quartz Veins.—Of these none indicating vertical and horizontal continuity have yet been located in the Cheticamp district. Much time has been spent by prospectors searching for quartz veins carrying free gold, but in this section conditions do not appear to have been favourable for the formation of such deposits. The belief so general with Nova Scotian prospectors that similar conditions to those found in the Atlantic gold-quartz series must prevail in all rocks of a slaty appearance, has here been followed by disappointment.

Principal Faults.—Probably the most powerful fault which traverses this belt is one with which the fluorite vein is connected. At the eastern end of Presqu'île, on the beach, black carbonaceous shale containing fossil fish remains is seen in close proximity to the schists. Here the fault (being parallel to the strike and hading with the dip) evidently conceals the basement beds of the Carboniferous formation which are seen at Jerome mountain, where, so powerful has been the effects of the fault, that the Carboniferous strata have not only been thrown on end but bent back upon themselves, thus reversing the order of their succession and giving them the appearance of dipping under the granites.

The next great fault is to be seen at the junction of the schists and granites at Corney brook. This fault appears to have a N.N.E. and S.S.W. course. From the wrinkled and crumpled condition of the schists here and the fact that they have been so intensely metamorphosed as to have a somewhat trachytic appearance, it would seem that considerable heat was developed during the upheaval of the granites.

CHAPTER II.

MANUFACTURE OF THE CRUDE BARYTES.

Treatment.—The mineral from the mine may either be shipped in the state it is delivered on the dump or it may first be passed through a rock breaker to reduce the lumps to such a size as may be found most suitable for handling in transit to the mill.

In Nova Scotia there are at present two mills reducing barytes to a powdered state. Messrs. Henderson and Potts, besides grinding for

their own use at the head of the Northwest Arm, Halifax, compete with the Eastern Milling Company at Dartmouth for the Canadian trade.

At the Dartmouth mill the rock is broken to the size of small nuts and then elevated to the washer, where in batches of three to six hundredweight it is subjected to an acid bath heated by steam pipes. Thence drained it is essential that it be carefully washed free of acid.* Dried, it is then pulverized and ground to the necessary degree of fineness between four horizontally revolving granite stones and French burs. In its floured state it is barrelled and shipped to the consumer. It is graded by tint, the whitest commanding the highest prices.

At the mill at the head of the Northwest Arm, which grinds from twenty to thirty tons per week, the ore is first hand-cobbed and separated into three grades, "white," "selected" and "off colour." Broken to the size of a hen's egg it is further reduced by cyclone crushers, after which it is elevated and riddled, the coarser particles returning to the crusher. The fine riddled material then passes between three French burstones and is barrelled. The presence of small quantities of fluorite is not considered detrimental to paints, as it grinds white.

When estimating the degree of purity in samples of the ground material, turpentine furnishes a ready test, a drop added to the powder having the property of causing the grades that are off colour to assume a still darker tint.

A variation is found in the degree of freedom with which ores from different localities are ground, the crystalline grinding more freely than the compact.

The barytes from Trinity bay, Newfoundland, has a pinkish tint which is hard to eradicate in the milling. It grinds easily down to the crystallized grain, but not beyond that degree of fineness, and, altogether, it is not so easy to grind as the ore from Stewiacke.

Uses of Barytes.—The earlier applications of barytes for purposes of trade were, broadly speaking, as an adulterant, for which its exceptional weight, cheapness and general absence of colour make it serviceable in many industries; in paints and putty; as a loading of rubber goods and pulverized sugar; for dressing calicoes and supplying a satisfying weight to French candies. But in addition to these purposes barytes has been found to possess a definite value of its own, as an ingredient of certain

*Laboratory of the Inland Revenue Department notes the presence of objectionable free acid in some samples submitted for analysis.

qualities of pulp colours and for the finish of wall papers. It supplies much of the barium used in the chemical trade for the manufacture of other compounds which have it as a base and are used for fireworks; it refines sugar and it is used for softening water in steam boilers. Barytes is also used in enamelling iron, paper collars, and oil cloths, and in coating canvas in which hams are packed; as a cheapener of white paints it is in chief demand. The Oil and Colourman's Diary, 1895, says of barytes:—"Whereas formerly this mineral was considered as an adulterant, it is now recognized that barytes has excellent qualities of its own that make it of value as a pigment. When it is used in combination with white lead or zinc, these qualities appear to advantage. Barytes has a pure white colour which is permanent, and it is unaffected by the weather or by gases that, in some instances, blacken white lead."

At the potteries of North Staffordshire, barytes has been used in the manufacture of certain wares, especially at Etruria, in the classic figures of Wedgewood ware. Mr. A. H. Church remarks that "the white particles of the barytes served to reflect the colours of the various oxides used as staining material for the differently tinted jaspers."

In some qualities of Paris green of German manufacture from eleven to twenty-five per cent of barytes is used as an adulterant.* In Canada, some years ago, an adulterated article was sold, containing up to fifty per cent, but now only pure paris green is supplied to the farmers.

The fitness of barytes as a pigment is due not merely to its weight and absence of colour, but to its aptitude to take colour-stain uniformly and make a small quantity of a decided colour cover much surface, a property not equally borne by other white substances, such as gypsum and marble, which the manufacturers of barytes for market find it desirable to remove by special treatment. Barytes acts as a base for aniline and certain other pigments.

Barytes, when manufactured for the paint trade, is known as *blanc fixe*, and is regarded as of special value as the only known white pigment that is unaffected by the weather. Zinc white is nearly permanent, but white lead discolours and even turns black after a time. In the trade barytes is regarded as decidedly useful for reducing white lead, although the admixture has not an equal covering power, and specific names are given to the various mixtures of certain manufacturers as "venice white," when the proportions are equal, "hamburg white," when the barytes is

*Engineering chemistry, T. B. Stillmann, 1900.

two parts to one of white lead, and "dutch white" when three parts of barytes are mixed with one of white lead.

The covering property of barytes varies with the degree of subdivision to which it is reduced and the method of its preparation. When artificially prepared, the sulphate is in a much finer state of subdivision than can be obtained by any method of grinding the natural sulphate, the mineral barytes; the covering power of the artificial sulphate far exceeds that of the ground mineral, especially while in the nascent state, for its exceptional value is partly lost by drying. The fineness of the former, also, is influenced by the strength of the barium chloride from which the sulphate is thrown down, the weaker solution yielding a precipitate of a greater covering capacity.

The method of preparing the various compounds of barium is described by J. Bersch,* who says:—"Enamel white, as usually prepared, is finely "ground barytes heated with coal, when it is converted into barium "sulphide; on this material the action of hydrochloric acid converts it "into barium chloride from which in solution there is precipitated by the "addition of sulphuric acid finely divided sulphate, enamel white. This "preparation is cheaper than white lead, but it is not so extensively used "in oil paints as it is in paper staining. Its value as a pigment largely "depends on its purity and freedom from acid by careful washing."

In Canada the admixtures of white lead and barytes have their local trade names. Several of these are mentioned in reports Nos. 78 and 91 of the Laboratory of the Inland Revenue Department, by which it appears that of 141 samples of white lead and oil offered for sale in Canada 100 were found to be pure; of the rest twenty-five, containing barytes, were sold under special names, the remainder being classed as adulterated. The reports call attention to the Act which prohibits the use of the terms "pure" or "genuine," unless the article has a specified composition, and which further defines an article as adulterated if any substance has been mixed with it so as to reduce, lower or injuriously affect its strength or quality.

Rubber Filling.—Incorporated in the dough as a filling, barytes is one of several inert substances used for that purpose by the rubber manufacturer, who, however, regards its want of colour as a detriment rather than an advantage. While the inductive capacity of vulcanized pure para rubber is 4 to 4.2, a capacity of 10 to 12 can be obtained by heavily oading it with the alkaline earths, baryta, &c. The capacity, however,

*Mineral Pigments, by J. Bersch, 1901, pp. 41-42.

is attended by a reduction of the dielectric strength, 15 to 20 kilovolts per millimetre is the standard, which strength is fairly sustained in some compositions containing sulphur and sulphuret of antimony, *e. g.*:

Para	58.	per cent.
Sulphur	2.	"
Talc	26.	"
Zinc oxide	14.	"
	100	

Besides those named the following materials are also used for loading rubber: infusorial earth (tripolite), whiting, Paris white, white and blue lead. It is difficult to obtain statistics regarding the use of barytes for this purpose, but an estimate given me places the annual consumption for loading rubber goods made in Canada at about 200 tons. In favour of barytes, it is claimed by manufacturers to add to the resiliency of rubber, to be of service in objects of bulky shape, such as carriage and other forms of springs and, when thickness is required, to fill up inequalities between joint faces and to prolong the life of the sheet packing so employed after the rubber and cloth insertion have become deteriorated by time and heat.

Sugar Refining.—In the clarification of saccharine juices which contain soluble mineral salts, and other organic bodies, the organic impurities are precipitated by boiling with milk of lime, a process which is called *defecation*. This may be carried too far with the formation of sucrates of lime and loss of sugar unless corrected by an acid, such as carbonic, with complex interchanges and possible imperfect purification.* A great improvement was effected in the process by double carbonation, and here in the second step of the treatment the possible use of a barium compound comes in, for European chemists have recognized that the oxide of barium is the best defecating agent, especially for the juice of sugar beets. It is the most active of the alkaline earths group: baryta, strontia and lime; but the last in the series, lime, is generally used on account of its cheapness, and doubtless because of the poisonous qualities of the soluble compounds of barium. Yet, in the use of baryta the precipitates are so insoluble that no trace of it remains in the sugar. In the year 1899-1900 some seventeen beet-sugar factories in France used baryta as an auxiliary to lime in the second carbonation, when it acted as a precipitant of impurities which the lime in the first half of the process did not throw down; but it does not seem to be so used in Canada.

The cost in this country of converting barytes into baryta and revivifying the carbonate in the waste is probably too great to be thought of

*The Technology of Sugar, by J. G. McIntosh, 1903, p. 130.

at present, so that an adoption of the French process would necessitate the importation of the barium hydroxide in its manufactured state.

According to "The Mineral Industry, 1903," the United Barium Co., of Niagara Falls, operates two furnaces of the direct heating arc type to produce twelve tons of barium hydrate a day. Each furnace uses 400 H.P. and requires 2,500 amperes at 120 volts and has an efficiency of 74 per cent. A ton of barytes so treated generates $S\ O_3$ sufficient to make half a ton of 50 per cent sulphuric acid. The statement is made with an implication that it is used for the separation of the uncrystallized sugar from molasses, baryta forming with sugar the compound $C_{12}\ H_{22}\ O_{11}\ Ba\ O$, which is then treated with carbonic acid gas; the barium separates as $Ba\ C\ O_2$, which is insoluble and thrown down.

Similar works for the manufacture, to be followed by similar application of this compound of barium, may be looked for in Canada so soon as the power plant under construction on the Canadian side of Niagara river is completed.

The United Barium Co. of Niagara Falls is said to own a mine of barytes near Silver islet on the north shore of Lake Superior, and "The Mineral Industry for 1903" further describes how an intimate mixture of 137 parts of pure barytes with seven to twelve parts of carbon is treated in the electric furnace with the following re-actions:—$4\ Ba\ S\ O_4 + 4\ C = Ba\ S + 4\ C\ O + 3\ Ba\ S\ O_4$ followed by $3\ Ba\ S\ O_4 + Ba\ S = 4\ Ba\ O + 4\ S\ O_2$. In the first part of the reaction the sulphate is transformed into sulphide and in the second the sulphate is decomposed into barium oxide and sulphur dioxide gas, the practical result being 60 per cent of barium oxide and 40 per cent barium sulphide.

CHAPTER III.

Value and Statistics.—The Report of the Department of the Interior at Washington for 1903 gives the value of crude barytes at from two to four dollars per ton, the variation being principally due to the grading of the mineral, No. 1, the whitest, bringing the highest price.

The same authority puts the value of barytes after it is cleaned and ground at $7.00 to $14.00 per ton. These figures are for the manufactured article ready for use as a pigment or for the manufacture of other compounds of barium. Of the imports of barytes into the United States the principal supply comes from Germany, with small amounts from

Canada and Newfoundland. In 1903 the value of the crude was $3.21 and that of the manufactured $8.54 per short ton.

"The Mineral Industry, 1903," of the United States, gives the following scale of prices:—

Domestic No. 1 Manufactured, $9.00 per ton of 2,000 lbs.
No. 2 at $8.00, and No. 3 at $7.75 per ton.
Imported German grey at $14.50 and white at $17.00.
Artificially prepared amorphous sulphate, blanc fixe, at two cents per pound.
Crude crystalline ore at $4.00 to $4.50, and flake at $3.50 per ton, f.o.b. cars Sweetwater, Tennessee.
In 1902 finished barytes brought $18.00 per ton.
In December, 1904, the crude ore imported from Newfoundland was invoiced at $2.50 per ton.

Mineral Rights.—The terms under which grants of lands in Nova Scotia have been conveyed from the Crown have varied from time to time in their reservations of mineral rights. Speaking generally it may be said that the ownership of minerals was surrendered by the Crown in 1858 to the grantee of the surface with the reservation only of gold, silver, lead, tin, copper and iron, and coal. The right to mine such minerals as gypsum, dolomite, barytes, &c., and such ores as those of manganese, &c., has since been exercised by the owner and occupier of the soil. But, in 1892, a change in Statutes required that all future grants from the Crown should reserve the mineral to be subsequently leased or otherwise dealt with as occasion may serve. This change does not affect the title to minerals in the lands held under grants of prior date, and as a source of revenue it is seriously doubted whether the change is worth while. The change does not encourage mining, nor ensure a better title to the prospector. It does, however, add to the complications regarding title, now sufficiently varied and exceptional for a country in which mining is so important an industry.

It has always to be remembered that the licenses to work minerals reserved by the Crown, as they are so designated, may carry with them a colour only of title. In practice there has been no guarantee from the Crown to the lessee that its reserved rights may not already have been transferred in whole or in part to others. Subsequent adjustment or appeal to the courts may be necessary to undisputed possession. With the late change in question an opening is given for further litigation in relation to squatters' rights obtained by lengthy occupation of lands. Rightly or wrongly, the present holders of ungranted lands consider that

their title acquired by occupation extends not only to the portions fenced but also to the unfenced portions of the lot they and their fathers have occupied in the range, marching with those held under grant by their neighbours; they further claim the minerals in their lands, a matter of grave importance to the mine worker, and it will be apparent that sound legal advice is now more than ever advisable in conducting a search of title.

From time to time statements, evidently incomplete, have been published of the barytes mined in Nova Scotia, the figures given being often only approximate, and it has not been possible to check them. Professor How sums up the output of 1866 as 500 tons from Five Islands, and 1,200 tons from Stewiacke, the two principal early sources of supply.

The first entries of barytes in the Reports of the Provincial Department of Mines were made by myself in 1874-7, and represented a total output of only 460 tons. The year 1879 shows 480 tons. Then, with the exception of 1881, with a forty ton product, there is no note until 1885–8 during which time the yield was 2,030 tons. A hiatus of nine years follows, succeeded by entries which sum up 4,000 tons to the end of 1903, and a total to that date of 8,670 tons. A separate memorandum of Messrs. Henderson and Potts gives the output at Stewiacke from August, 1886, to June 1889 as 760 tons and from August, 1891 to August, 1900 as ninety-six tons.

BARYTES IN CANADA.

Production.			Imports.*		
Year.	Tons.	Value.	Year.	Cwt.	Value.
		$			$
1885	300	1,500	1880	2,230	1,525
1886	3,864	19,270	1881	3,740	1,011
1887	400	2,400	1882	497	303
1888	1,100	3,850	1887	379	676
1890	1,842	7,543	1888	236	214
1892	315	,260	1889	1,332	987
1894	1,081	2,830	1890	1,322	978
1896	145	715			
1897	571	3,060			
1898	1,125	5,533			
1899	720	4,402	Note.—Since 1890 the imports of barium compounds have not been separately entered by the Customs Department.		
1900	1,337	7,605			
1901	653	3,842			
1902	1,096	3,957			

Note.—The above is the record of the Section of Mines of the Geological Survey Department.

*Subject to a duty of 20%.

For the purpose of showing the value of barium compounds as articles of trade and commerce, the following is inserted:—

Imports into the United States in 1903 of barium compounds other than barytes—

Witherite, barium carbonate.	$35,762.00
Barium binoxide.	84,549.00
Barium chloride.	68,762.00
Barium sulphate, artificial; blanc fixe.	35,466.00

All of these compounds have a very much higher value than natural barytes. The artificial sulphate, for instance, is valued at $25.72, as compared with the mineral barytes at $9 per ton.

PRODUCTION OF CRUDE BARYTES, 1882-1903, IN THE UNITED STATES.

Year.	Quantities in Short Tons.	Value.	Average price per Ton.
		$	$
1882-1892.	254,388	1,039,206	4 07
1893-1896.	90,902	290,323	3 19
1897.	26,042	58,295	2 23
1898.	31,306	108,339	3 50
1899.	41,894	139,528	3 33
1900.	67,680	188,089	2 78
1901.	49,070	157,844	3 22
1902.	61,668	203,154	3 29
1903.	50,397	152,150	3 02

Importations of barytes, both crude and manufactured, into the United States.

Year.	Manufactured.		Crude.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.	$	Short tons.	$
1882-1892.	11,557	183,235	35,753	89,757
1893-1899.	10,062	107,889	11,150	32,462
1900.	2,454	24,160	2,568	8,301
1901.	2,454	27,062	3,150	12,380
1902.	3,908	37,389	3,929	14,322
1903.	5,716	48,726	7,105	22,777

NOTE.—The import duty into the United States is $1.12 per ton on crude barytes, and $6.72 per ton on the manufactured article.

STRONTIUM.

A few words on strontium naturally accompany a report on barytes, both being employed for the same economic purposes.

In spite of its poisonous nature, baryta (barium hydroxide) is used, especially in Germany, in beet-refining factories. So long as sugar-refiners are amenable only to the ordinary laws of human nature, and are not prevented by the special laws of government, so long will baryta continue to be thus used. It is twice as cheap as strontianite in the form of strontium hydrate. Principally owing to the cheapness of barytes, the mining of strontium on the American continent has never, so far as the writer is aware, been on a commercial basis, nor is it likely to be until laws are passed prohibiting the use of barium hydroxide in sugar-refining.

The other chief use of strontianite, in the form of strontium nitrate, is in pyrotechny, to which it supplies the well-known strontia-red.

The known occurrences of strontianite in Canada are few, though it is possible that some of the at present supposed deposits of barytes contain strontianite.

"On the south shore of the Ottawa river, a short distance below the road leading down to the old Skead mill, on lot 31, concession A of Nepean township, strontianite occurs in the form of veins, traversing the lower part of the Chazy limestone and varying from four to six inches in thickness. The mineral occurs below high-water line and thus can only be seen at a low stage of the river." Mr. Johnston's analysis of carefully selected crystals dried at 100° C. gave—

Carbonic acid	30.54
Strontia	65.43
Lime	3.38
Insoluble	0.17
	99.52*

Mr. C. W. Willimott writes: "When the mineral is first extracted, the colour, near the middle of the vein, is pale apple-green, merging into almost white as it approaches the walls."

*Geol. Surv. of Can., 1899, Pt. G, p. 44.

The consumption of strontium salts in the United States is, at present, very small, the total value of the imports for 1903, nearly all of which were said to come from Germany, amounting to only $1,337.

The chief strontium mines are at Strontian (Scotland); Yorkshire; at the Giant's Causeway (Ireland); Saxony; Saltzburg, and in the Harz mountains.

At the present time Scotland is shipping strontia to Germany. The strontia mined in the United Kingdom from 1884 to 1892 amounted to 87,852 tons, valued at $290,160.

Celestite, so called from its delicate blue colour, is found in orthorhombic crystals, resembling in form those of barytes. It occurs principally in Sicily, finely crystallized, with native sulphur. It is reported to occur on Strontian island, in Lake Erie. Of its occurrence in Canada, which is very rare, Mr. C. W. Willimott writes:—

"This mineral occurs in veins in the Laurentian and Cambro-Silurian rocks. In the township of Lansdowne, in the province of Ontario, an important vein, made up of large modified crystals of a light bluish and reddish colour, occurs; the crystals are often so densely packed as to obliterate their terminal edges, giving it the appearance of a crystalline mass.

In the township of Bagot, in the same province, a white, fibro-bladed mineral occurs in diverging and reticulating masses, often associated with tremolite. This latter mineral has the same colour and similar external characteristics, and may often be mistaken for celestite, but may, however, be easily detected by its greater hardness. The vein appears to be of some importance, but could not be properly examined during my last visit owing to the thick covering of snow.

In the city of Kingston white semi-fibrous crystalline celestite mixed with calcite and blende occurs in a bed of Black River limestone along the lake shore for half a mile west of Barrie street.

At the forks of the Credit, in the township of Caledon, nodules, often several inches across, of a reddish, tabular, crystalline mineral occur in the Niagara limestone, which also encloses selenite and calcite.

In the township of Hawkesbury, in the province of Quebec, a light bluish fibrous mineral occurs in thin veins in limestone and shale."

Mr. Hugh Fletcher* reports having found celestite on the right bank of Sydney river, about a mile and a half above Sydney bridge, where a bluish grey bed, about one foot thick, containing specks of galena, may be seen for a considerable distance along the stream, overlaid by grey, slaty limestone.

NOTE.—At Lake Ainslie the open cut at the top of the hill is some 300 feet in length and has at its eastern end a cavity some 50 feet deep where the deposit continues to hold its full width.

On the west front of the hill the lowest tunnel has been driven over 300 feet, the barytes carrying a width of 12 to 16 feet with a clay gouge on the foot wall.

Near Outlet the ore has been found 6 feet wide on E. Campbell's land and has been traced south on McKinnon's property 2000 feet. On the former a sinking for 40 feet has yielded some 2500 tons of white ore the chief source of output of late.

*Geol. Surv. of Can. Report for 1875-76, p. 418.

UNGAVA AND LABRADOR.

217. Hudson Strait and Bay, by R. Bell. 1885. (15c.)
267. James Bay and east of Hudson Bay, by A. P. Low. 1887-88. (25c.)
584. Labrador Peninsula, by A. P. Low. 1895. (30c.)
657. Richmond Gulf to Ungava Bay, by A. P. Low. 1896. (10c.)
680. Hudson Strait (south shore) and Ungava Bay, by A. P. Low. 1898. (15c.) } Bound together.
713. Hudson Strait (north shore), by R. Bell. 1898. (20c.) } Bound together.
778. Hudson Bay, east coast, by A. P. Low. 1901. (25c.)
819. Nastapoka Islands, Hudson Bay, by A. P. Low. 1901. (10c.)

NEW BRUNSWICK AND NOVA SCOTIA.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. (20c.)
219. Carleton and Victoria cos., by L. W. Bailey. 1885. (20c.)
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(B.—*Published by the Mines Branch.*)

On the location and examination of magnetic ore deposits by magnetometric measurements. Eugene Haanel. 1904.

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GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DIRECTOR

REPORT

OF THE

SECTION OF CHEMISTRY AND MINERALOGY

BY

G. CHRISTIAN HOFFMANN, LL.D., F.I.C., F.R.S.C.,
Chemist and Mineralogist to the Survey.

ASSISTANTS

F. G. WAIT, M.A., F.C.S.
R. A. A. JOHNSTON.

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TABLE OF CONTENTS.

REPORT

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MISCELLANEOUS MINERALS.

1. Souesite.

A native iron-nickel alloy occurring in the auriferous gravels of the Fraser, B.C.

In washing the material obtained in dredging for gold in the Fraser river, two miles below Lillooet, it has been found that there remains, at the time of cleaning up, a fine, heavy, greyish sand, having a metallic aspect. A sample of this sand, which was sent to the writer for identification, has been examined and found to consist, essentially, of an aggregation of small, very irregular-shaped, rounded grains of an iron-nickel alloy and small to minute, flattened, rounded, steel-grey, glistening scales of native platinum; intermingled with which were some minute, bright, steel-grey coloured, irregular-shaped, flattened grains of iridosmine, a few flattened grains of native gold, some minute partially rounded crystals of magnetite, a few equally small grains of ilmenite, and a few particles of quartz and of garnet. Of the foregoing, the grains of the iron-nickel alloy constituted, approximately, forty-seven per cent, and those of the native platinum forty-three per cent, by weight, of the whole; the grains of iridosmine, native gold, magnetite, ilmenite, and of quartz and garnet, making up the balance of ten per cent.

This iron-nickel alloy occurs, as above described, in the form of small, very irregular-shaped, rounded grains, the largest not exceeding a millimetre and a half in diameter, whilst many, indeed the greater number, were of far smaller dimensions, and others were of microscopic minuteness. It has a faint yellowish steel-grey colour, and a subme-

tallic lustre; is strongly magnetic, and malleable. Its specific gravity, at 15·5° C., is 8·215. The mineral is very slightly acted upon by hydrochloric acid in the cold; upon the application of heat, however, it slowly passes into solution. It is readily attacked by dilute nitric acid, even in the cold, and is easily and completely dissolved by it on heating.

The mean of two closely concordant analyses, conducted by Mr. F. G. Wait, upon carefully selected material, showed it to have the following composition:—

Nickel	75·50
Cobalt	none.
Iron	22·02
Copper	1·20
Insoluble siliceous matter	1·16
	99·88

Deducting the insoluble siliceous matter, and recalculating the remaining constituents for one hundred parts, we obtain, as representing the composition of the mineral:—

Nickel	76·48
Iron	22·30
Copper	1·22
	100·00

There are only two instances on record of a mineral similar to that above described having been met with. One of these is the nickeliferous iron called "awaruite," referred to by W. Skey (Trans. N. Zeal. Inst., vol. 18, p. 401, 1885) as having been found, associated with gold, platinum, cassiterite, chromite, and magnetite, in the drift of the Gorge river, a stream flowing into Awarua bay, on the west coast of the South island of New Zealand; and the other, the iron-nickel alloy described by A. Sella (Compt. Rend., vol. 112, p. 171, 1891) as occurring in the auriferous sands of the Elvo, a mountain-stream near Biella, Piedmont, Italy.

As tending to facilitate a comparison of these three apparently closely related minerals with each other, their analyses are here given in a tabular form, — (1) being the analysis of the nickeliferous iron "awaruite"; (2) that of the iron-nickel alloy from the Elvo, Piedmont; and (3) the analysis, after deducting some insoluble siliceous matter and recalculating the remaining constituents for one hundred parts, of the iron-nickel alloy from the Fraser river.

	G	Fe	Ni	Co	Cu	S	SiO_2		
(1)	8·1	31·02	67·63	0·70	..	0·22	0·43	=	100·0
(2)	7·8	26·60	75·20*		..	..	..	=	101·8
(3)	8·215	22·30	76·48	..	1.22	..	..	=	100·0

*Nickel, with some cobalt.

The writer suggests that this mineral be named "souesite," after Mr. F. Soues—to whom he is indebted for the sample sent for identification—to distinguish this find from that of other naturally occurring iron-nickel alloys.

MINERALOGICAL NOTES.

1.—Agate-jasper. A large fragment, apparently part of a water-worn mass, of brownish-red jasper with bands and veinings of a light bluish-grey, in parts light lavender-blue, chalcedony, and which represents a fine example of agate-jasper, has been found in the detritus of the Fraser river, at Big Bar, Lillooet district, B. C.

2.—Arquerite. Several small irregular shaped pellets of this mineral—a native silver-amalgam, which is commonly referred to by the British Columbian miner as silver, owing to its presenting the outward appearance of native silver,—the largest not exceeding a grain and a half in weight—have been handed to me by Mr. R. G. McConnell. They were found, accompanying coarse native gold and nuggets of native copper, in the auriferous gravel of Burwash creek, a tributary of Kluane river, a stream flowing out of the northern end of Kluane lake, Ykn.

3.—Bismuth, Native. Very irregular-shaped pellets, of from two to seven decigrammes in weight, of what on examination proved to be native bismuth with, in some instances, a little partially embedded native gold, were found in a sample of material taken by Mr. J. Keele from the riffles of a sluice-box, on Highet creek—a tributary of Minto creek, which flows into Mayo river, and through the latter into the Stewart river, Ykn.

4.—Calcite. Fine groupings of rhombohedral crystals of a light to dark, rich yellowish-brown calcite, have been found, together with isolated crystals and crystal aggregates of a sky-blue celestite, on the surface of fissures or cavities in a brownish-grey fossiliferous dolomite met with in cutting a channel in the

bed of the Detroit river at Amherstburg, Malden tp., Essex co., Ont.; and fine masses of a yellowish-white, greenish-yellow, and yellowish-green, sub-translucent to translucent, calcite having a fine-columnar, radiated, and concentric structure, have been met with by Prof. R. W. Brock at the Black Prince claim at the head of Gainer creek, a tributary of the South fork of Lardeau creek, which flows into Trout lake, West Kootenay dist., B. C.

5.—CELESTITE. Large, isolated, more or less perfect, sky-blue, translucent, tabular crystals of celestite—some of which measure three inches in length and two inches and a quarter across, and groupings of similar, but smaller, crystals have been found implanted on the surface of fissures or cavities in a brownish-grey fossiliferous dolomite met with in cutting a channel in the bed of the Detroit river at Amherstburg, Malden tp., Essex co., Ont.

—CHALCEDONY. A very interesting occurrence of this mineral has been observed by Mr. R. A. A. Johnston at the Maggie claim, in Aspen Grove camp, Similkameen' div., B.C., where he found it lining the walls of an extensive vertical fissure in a reddish-grey andesite. Some of the specimens obtained by him at this locality are exceptionally fine, and represent an incrustation of some two inches and a quarter in thickness, made up of closely aggregated, frequently coalescing, drooping, stalactitic forms of a light ash-grey, occasionally bluish-grey, translucent chalcedony.

7.—CHERT. Among other specimens received from the Rev. Thomas Nattress for identification, was a fragment of a nodule of greyish-white to white, opaque, dull, chert or hornstone, to which is attached a little celestite and bituminous calcite, found in a brownish-grey fossiliferous dolomite met with in cutting a channel in the bed of the Detroit river at Amherstburg, Malden tp., Essex co., Ont.

8.—COBALTITE,—*see under* NICCOLITE.

9.—COPPER, NATIVE. Irregular-shaped, flattened masses of native copper of six and seven or more pounds in weight have been found by Mr. R. A. A. Johnston filling fissures in a purple andesite at the Sovereign claim, in Aspen Grove camp, Similkameen div., B. C.; and variously sized rounded masses of

native copper are frequently met with in the auriferous gravel of Burwash creek, a tributary of Kluane river, Ykn. One such, collected by Mr. R. G. McConnell, consists of a more or less kidney-shaped nugget, weighing one pound five and three-quarter ounces, in parts coated with a little cuprite and malachite.

10.—EPSOMITE. Specimens of this mineral, in the form of greyish-white friable masses have recently been handed to the writer by Mr. J. Keele, with the information that the same had been collected by Mr. C. Camsell, who had met with this salt, in some little abundance, at Alum hill, on Peel river, Ykn., and had also found it as a thin incrustation on the clay banks of that river in many places farther up stream between Alum hill and the mouth of Snake river, a distance of some twenty miles.

11.—GOLD, NATIVE. Some very pretty wire-like forms of native gold, one of which measures twenty-two millimetres in length and a little over one millimetre in diameter, have been obtained by Mr. J. Keele, in the course of working for gold on Highet creek, a tributary of Minto creek, Mayo river, Ykn.

12.—LEAD, NATIVE. A sample of material—received by the writer from Mr. W. J. B. Pinder, for identification—which had been found among the native gold obtained in washing auriferous gravel at the Lippy claim on Eldorado creek, Klondike dist., Ykn., was found to be composed of rounded, flattened, grains of native gold united together by a network of lustrous, bluish-grey, native lead which in parts exhibits a globular surface.

13.—LIMONITE. There has recently been presented to the Museum a fragment of limonite—apparently part of a nodular mass of that mineral—having a concentrically arranged radiating fibrous structure, which was found by the donor on Grindstone island, one of the Magdalen group, in the Gulf of St. Lawrence. Hematite has, it may be observed, been met with, by Mr. James Richardson, in the form of rounded nodules—an analysis of one of which is given in the Report of Progress for 1879-80, p. 15 H—amongst the debris of the fallen cliff immediately under Demoiselle hill, on Amherst island, which lies about ten miles south of Grindstone island, above referred to. Neither occurrence has, it is anticipated, other than a scientific interest.

14.—LIMONITE, pseudomorph after pyrite. A fine, although imperfect, pentagonal dodecahedron of limonite, pseudomorph after pyrite, measuring some six centimetres across, the faces of which are deeply striated, has been presented to the Museum by M. C. H. Pollen, who informs me that it was found in a small deposit of iron-ore on Bull river, about six miles up from its entry into the Kootenay river, B. C.

15.—MOLYBDENITE. This mineral has been met with, by Mr. Anthony Dacy, on lot 6, range XII of Eardley tp., Wright co., Que., where it occurs—as shown by the specimens which were brought by him to the Survey for examination—in the form of thin to stout foliated masses, associated with pyrite, distributed through a gangue composed of quartz and feldspar with a little hornblende. Molybdenite has also, somewhat recently, been met with at what is known as the Tamarac group of claims, situated on Gnawed mountain, Highland valley, Yale dist., B. C. A sample of material from one of the veins constituting the group in question, which was received for examination, was found to consist of a white translucent quartz traversed by thin layers of a, for the most part, very fine-granular molybdenite, and also carrying small quantities of chalcopyrite.

16.—MORION. Fairly well-formed, singly terminated, hexagonal prisms, measuring, in some instances, an inch or more in diameter, of pitch-black to velvet-black, opaque, quartz,—constituting what is known as 'morion,' a variety of quartz, have been found by Mr. E. R. Faribault in a vein of coarse pegmatite cutting a ridge of granite just west of Joe Bill brook, a tributary of Gold river, and one mile west of Sefferensville post-office, Chester tp., Lunenburg co., N. S.

17.—NICCOLITE. Among some of the more recently received mineral specimens sent for identification, was one consisting of a compact, massive, niccolite, through which is distributed a little cobaltite, which was found by Mr. J. Boyer on lot No. 287, on McIntyre street, in North Bay, Widdifield tp., Nipissing dist., Ont.; and another, consisting of niccolite, with some cobaltite, and a little native silver, in a gangue composed of a ferruginous dolomite, which had been found on lot 22, con. A, Widdifield tp., or about two miles and a half north-northwest of the first mentioned occurrence.

18.—Platinum, Native. Small irregular-shaped grains and scales of native platinum, together with a few scales of native gold, and an occasional grain of pale brownish, translucent corundum, were found to enter into the composition of a sample of black sand—sent to the writer for examination, from the riffles of a sluice-box at Pine creek, about a mile and a half below Atlin, B.C. Native platinum has likewise been found by the writer to occur, in very appreciable quantity, in the form of small to minute, flattened, rounded, steel-grey, glistening scales, with small irregular-shaped, rounded grains of souesite—a native iron-nickel alloy, flattened grains of native gold, and some minute, flattened grains of iridosmine, in a sample of heavy greyish sand left as a residuum in washing the material obtained in dredging for gold in the Fraser river, two miles below Lillooet, B.C.

19.—Polycrase.—This mineral, which was first met with in Canada —as described in Annual Report for 1898, vol. xi, p. 14 R, in a coarse granite vein, on lot 19, con. 9, Galvin tp, Nipissing dist., Ont., has since been found to occur some twenty-five miles to the east of this in a coarse granite vein which cuts the biotite gneiss on lot 7, concession A of Cameron tp., Nipissing dist., Ont. The latter vein is composed, as may be inferred from a large quantity of material collected by Mr. C. W. Willimott to represent its components, of a light to somewhat dark greyish, translucent quartz, a light hyacinth-red to tile-red orthoclase, a verdigris-green to bright apple-green microcline—amazon-stone, muscovite, and a little biotite, together with masses of a light greyish-green fluorite, some inclusions of a brownish-red calcium iron-garnet—andradite, and an occasional small crystalline mass of polycrase. In addition to the polycrase thus occurring scattered through the vein, Mr. Willimott found in a drusy cavity of the same an implanted crystal of what he conjectured might be the same mineral, and this on examination it proves to be. It measures about seventeen millimetres in diameter, and shows well defined terminal faces.

20.—Pyrargyrite. This mineral was found by Mr. F. G. Wait to occur, associated with argentite, stephanite, argentiferous tetrahedrite, argentiferous galena, sphalerite, arsenopyrite, pyrite, and some scales of native silver, scattered through a white, sub-translucent to translucent quartz, in a series of

specimens, collected by Mr. R. G. McConnell, from quartz veins at, respectively, the Montana and the M. and M. claims, on the west side of Windy Arm, a southerly branch of Tagish lake, Ykn.

21.—PYROPHYLLITE. A light greenish-grey, sub-translucent, compact pyrophyllite, has been met with by Mr. Hugh Fletcher, but not in any great quantity, in the form of thin layers traversing the felsites and quartzites of the Pre-Cambrian at Eagle Head, Gabarus bay, Cape Breton co., N.S.; and a similar, but somewhat lighter coloured variety occurs, in some abundance, in the Pre-Cambrian felsites of Kennington cove, about three miles west of Rochefort (on some maps incorrectly spelt Rochford) point, at the entrance of Louisburg harbour, in the same county.

22.—SCHEELITE. This mineral (which was first met with, in Canada, in Nova Scotia and Quebec, as mentioned by the writer in some of his previous reports—Rept. Geol. Surv. Can., vol. v, p. 21 R, 1890-91, and vol. vii, p. 14 R, 1894), is occasionally found to occur in the auriferous gravels of some of the streams in the Yukon, as evidenced by two samples of material taken by Mr. J. Keele from the riffles of sluice-boxes at, respectively, Dublin gulch, on Haggart creek, a tributary of the McQuesten, which flows into the Stewart; and Highet creek, a tributary of Minto creek, which flows into Mayo river. Of these samples, that from Dublin gulch was found to consist of a fine to coarse sand composed of small rounded grains of white scheelite with a few intermingled particles of quartz and of hematite and a little native gold; whilst that from Highet creek contained numerous pellets, the largest of which measured one centimetre in diameter, of a white, translucent scheelite having a vitreous lustre. Scheelite has also been met with, and in some quantity, at the following localities in British Columbia, namely, at the Dawson and Mabel claims on Hardscrabble creek, a tributary of Willow river, Cariboo dist., where a cream-yellow, sub-translucent, massive scheelite is found, associated with galena, in small quartz veins of from one to four inches in width, some of which have been found to contain as much as eighty per cent of the mineral; and at the Meteor mine on Springer creek, a stream flowing into the southern extremity of Slocan lake, in the West Kootenay dist., where a yellowish-brown, in parts straw-yellow, opaque, massive

scheelite occurs, in the quartz, in the form of lenticular masses of from one to three feet in length, two to three inches in width.

23.—SELENITE. Fine clear, colourless, isolated crystals, and penetration-twins, of this mineral have been found by Mr. A. Saint Cyr, in the mud banks on the Simonette river—a tributary of Smoky river—about where it is crossed by the sixth meridian.

24.—SILVER, NATIVE. Handsome specimens of fine-filiform native silver—one of which has recently been presented by Dr. John Thorburn to the Museum—have frequently been found, with argentiferous galena and decomposition products of the same, some sphalerite, and a little chalcopyrite and pyrite, at the 'Number One' mine, situated about two miles due west of the town of Ainsworth, on Kootenay lake, B.C. Native silver has also, and that quite recently, been met with—as indicated by specimens received for examination—in the form of leafy, occasionally granular, masses, accompanied by very small quantities of sphalerite and pyrite, freely scattered through a two inch vein of light to dark grey, sub-translucent quartz, in a mineral claim at the headwaters of McGillivray creek, a stream flowing into Anderson lake, Lillooet dist., B.C.

25.—SPHALERITE. A coarse-granular to compact, massive, cleavable, dark brownish-red to almost black blende, with which is occasionally associated some galena, a little pyrite and, more rarely, some minute brownish-yellow crystals of idocrase, has been met with, in some abundance, forming veins, stringers, and pockets in a crystalline limestone of the Grenville series, on lot 3, con. 5 and lot 3 of con. 6, Olden tp., Frontenac co., Ont. A somewhat coarse, crystalline, massive, black blende, has likewise been met with, but only in comparatively small quantity on lot 10, range XII, Eardley tp., Wright co., Que.

26.—STEATITE. A light grey, feebly lustrous, sub-transparent, compact steatite has been met with, but, as yet, only in limited quantity, in connexion with the crystalline limestones of Skye mountain on the north bank of Brigend brook, about two miles up from its entry into Whycocomagh bay, Inverness co., N. S.

27.—STEPHANITE. This species—one not previously known to occur in Canada, has been recognized by Mr. F. G. Wait as occurring, with argentite, pyrargyrite, argentiferous tetrahedrite, argentiferous galena, pyrite, arsenopyrite, sphalerite, and some scales of native silver, scattered through a white, sub-translucent to translucent quartz, in a series of specimens, collected by Mr. R. G. McConnell, from quartz veins at, respectively, the Montana and the M. and M. claims, on the west side of Windy Arm —a southerly branch of Tagish lake, Ykn.

28.—STIBNITE. A bluish ash-grey, fine-granular, massive, argentiferous stibnite, has recently been met with, in some abundance, in an auriferous quartz vein some three feet in width, at the southeast end of Chilco lake, about thirty-two miles east by north of the head of Bute inlet, Strait of Georgia, B. C.

29.—TALC. Some fine specimens of a yellowish-green, translucent, in thin laminæ transparent, talc, with a pearly lustre, have been received by the writer from Mr. G. V. M. Temple, with the information that they were obtained by him from a deposit of this mineral on cadastral lot 683 of lot 2 of Craigs Road range, or range II, Ireland tp., Megantic co., Que.

30.—VESUVIANITE. A yellowish-green, compact, massive variety of vesuvianite has been met with forming, as observed by Mr. R. A. A. Johnston, a vein, of some six or seven inches in thickness, cutting the limestones and schists at Charley cove, on the northwest side of Frye or Cailiff island, on the southern coast of Charlotte co., N. B.

COALS AND LIGNITES.

[Continued from page 25 R of the Annual Report— vol. xiii, 1900.]

104.—LIGNITE. From the vicinity of Roche Percée, Souris river, Sask. Geological position—Tertiary.

This fuel was received, owing to exposure to the atmosphere, in a very broken-down condition.

An analysis, by fast coking, gave :

Hygroscopic water	20·29
Volatile combustible matter	31·41
Fixed carbon	31·35
Ash	16·95
	100·00
Coke, per cent	48·30

Ratio of volatile combustible matter to fixed carbon 1 : 0·998.

It yields, by fast coking, a non-coherent coke. Colour of the ash, pale reddish-white.

105.—LIGNITE. From the Souris river, one mile west of La Roche Percée, at the junction of Short creek and Souris river, Sask. Geological position—Tertiary.

There are, agreeably with the observations of the late Dr. A. R. C. Selwyn, then Director of the Survey, three distinct seams of lignite exposed at the above mentioned locality. Of these, the uppermost, which is some fifteen or sixteen feet below the surface, has a thickness of two feet. Immediately beneath this there is a one-foot-six-inch layer of clay shales, followed by a five-foot seam of lignite. This, in turn, is succeeded by fifty feet of a soft whitish sand-rock, at the base of which there is another seam of lignite, which has a thickness of three feet.

The following are the results of an examination of a sample of the material from the above referred to five-foot seam.

A brownish-black, compact lignite ; ligneous texture very marked ; lustre, for the greater part, dull, in more altered parts, sub-resinous to resinous ; tough ; fracture, on the whole, uneven, occasionally, however, verging on the sub-conchoidal, does not soil the fingers ; powder, black with a brownish tinge ; it communicates a deep brownish-red colour to a boiling solution of caustic potash ; by exposure to the air becomes more or less fissured and falls to pieces.

An analysis, by fast coking, gave :

Hygroscopic water	21·84
Volatile combustible matter	35·12
Fixed carbon	38·64
Ash	4·40
	100·00
Coke, per cent	43·04

Ratio of volatile combustible matter to fixed carbon 1 : 1·10.

It yields, by fast coking, a non-coherent coke. The ash has a brownish-yellow colour, and when exposed to a bright red heat it becomes slightly agglutinated.

106.—LIGNITE. From a deposit in tp. 63, on or near Towtinow river, at a point some eighteen miles south-southwest of Athabaska Landing, Alta. Structure, fine-lamellar, compact; colour, black, inclining to brownish-black; lustre, dull to sub-resinous; fracture, on the whole, uneven, but occasionally verging on the sub-conchoidal; powder, blackish brown; it communicates a deep brownish-red colour to a boiling solution of caustic potash. On exposure to the air it splits along the plane of bedding and falls to pieces.

An analysis, by fast coking, gave:

Hygroscopic water	19·45
Volatile combustible matter	34·34
Fixed carbon	41·86
Ash	4·35
	100·00
Coke, per cent	46·21

Ratio of volatile combustible matter to fixed carbon. 1:1·22.

It yields, both by slow and fast coking, a non-coherent coke. The ash has a brownish-yellow colour.

107.—LIGNITE. From Kneehills creek, a tributary of Red Deer river, Alta. Geological position—Lower Laramie, Edmonton series. Structure, somewhat coarse lamellar, compact,—made up of alternating layers of a greyish-black, dull, and dense, bright, black lignite, the latter layers exhibiting, in many instances, a distinct ligneous structure; fracture, on the whole, uneven, that of the denser layers, sub-conchoidal; does not soil the fingers; powder, brownish-black; it communicates a deep brownish-red colour to a boiling solution of caustic potash; by exposure to the air it becomes fissured, preferably along the line of bedding, and falls to pieces.

An analysis, by fast coking, gave:

Hygroscopic water	13·28
Volatile combustible matter	36·69
Fixed carbon	43·84
Ash	6·19
	100·00
Coke, per cent	50·03

Ratio of volatile combustible matter to fixed carbon 1 : 1·19

It yields, both by slow and fast coking, a non-coherent coke. The gases evolved during coking burnt with a yellowish, somewhat luminous, almost smokeless flame. The ash, which has a reddish-brown colour, becomes agglutinated at a bright red heat, and at a most intense red heat it forms a vitrified mass.

108.—LIGNITE. From a seam eleven and three-quarter miles up Coal creek,—a stream flowing into the Yukon five miles below the mouth of Fortymile river, Ykn. Seam four to eleven feet thick. Geological position—Tertiary. Collected by Mr. R. G. McConnell.

Structure, somewhat coarse lamellar—made up of layers of a greyish-black, dull, and bright, black coal ; contains, in parts, a little lemon-yellow and brownish-yellow, sub-transparent resin ; fracture, uneven ; does not soil the fingers ; powder, blackish-brown ; it communicates a dark brownish-red colour to a boiling solution of caustic potash ; by exposure to the air becomes fissured, but is, on the whole, tolerably hard and firm.

An analysis, by fast coking, gave :

Hygroscopic water	6·03
Volatile combustible matter	38·44
Fixed carbon	50·53
Ash	5·00
	100·00
Coke, per cent	55·53
Ratio of volatile combustible matter to fixed carbon	1 : 1·31

It yields, both by slow and fast coking, a non-coherent coke. The gases evolved during coking burn with a yellowish, somewhat luminous, very slightly smoky flame. The ash, which has a light reddish-brown colour, agglutinates at a bright red heat, and at a most intense red heat it becomes slightly fritted.

109.—LIGNITIC COAL. From a seam not far from Roche Percée, Souris river, Sask. Geological position—Tertiary.

This fuel, owing to a lengthened exposure to the atmosphere, was received in a broken down condition.

An analysis, by fast coking, gave:

Hygroscopic water	5·95
Volatile combustible matter	13·65
Fixed carbon	67·58
Ash	12·82
	100·00
Coke, per cent	80·40
Ratio of volatile combustible matter to fixed carbon	1 : 4·95

It yields, by fast coking, a non-coherent coke. Colour of the ash, light reddish-brown. It communicates a brownish-yellow colour to a boiling solution of caustic potash.

110.—LIGNITIC COAL. From a seam on a branch of Ruby creek, a tributary of Indian river, Ykn., about seven miles up from the mouth of the creek. Geological position—Tertiary. Collected by Mr. R. G. McConnell.

Structure, moderately coarse lamellar—made up of alternating layers of a greyish-black, dull, and bright, black lignitic coal; contains, here and there, small particles of brownish-yellow sub-transparent resin; fracture, uneven; powder, black, with a slight brownish tinge; it communicates a dark brownish-red colour to a boiling solution of caustic potash; by exposure to the air becomes fissured, and has a tendency to fall to pieces.

An analysis, by fast coking, gave:

Hygroscopic water	4·68
Volatile combustible matter	29·88
Fixed carbon	60·06
Ash	5·38
	100·00
Coke, per cent	65·44
Ratio of volatile combustible matter to fixed carbon	1 : 2·01

It yields, both by slow and fast coking, a non-coherent coke. The gases evolved during coking burn with a yellowish, somewhat luminous, almost smokeless flame. Colour of the ash, reddish-white. The same, when submitted to a bright red heat becomes agglutinated, whilst at a most intense red heat it becomes fritted.

111.—Lignitic coal. From tunnel on the Jackson seam on Quilchena creek, five miles from its entry into Nicola lake, Yale dist., B.C. Thickness of seam, six feet. Geological position—Tertiary. Collected by Dr. R. W. Ells.

Structure, fine lamellar,—compact; is made up of thin layers of a brownish-black, dull coal with an occasional interposed layer of a jet-black, highly lustrous variety of the same; fracture, uneven, that of the bright layers, sub-conchoidal; does not soil the fingers; colour of powder, blackish-brown; it communicates a brownish-red colour to a boiling solution of caustic potash; when freshly mined, is hard and firm, but by exposure to the atmosphere it becomes more or less fissured and has a tendency to fall to pieces.

An analysis, by fast coking gave:

Hygroscopic water	6·95
Volatile combustible matter	37·21
Fixed carbon	47·95
Ash	7·89
	100·00
Coke, per cent	55·84
Ratio of volatile combustible matter to fixed carbon	1 : 1·29

It yields, by fast coking, a firm coherent coke. Colour of the ash, pale reddish-brown.

112.—Coal. From a seam on the north side of the north fork of Oldman river, about half a mile east of Ernst creek, section 35, tp. 10, range III, west of the fifth initial meridian, Alta. Seam said to be thirty feet thick. Geological position—Cretaceous, lower than Pierre shales, probably Kootanie series.

Structure, lamellar, compact, the lines of bedding are at times somewhat indistinct; is made up of a greyish-black, dull, and dense bright black coal; shows slickensides; slightly soils the fingers; is hard and firm; fracture, uneven; powder, brownish-black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by fast coking, gave:

Hygroscopic water	1·03
Volatile combustible matter	32·20
Fixed carbon	61·28
Ash	5·49
	100·00
Coke, per cent	66·77
Ratio of volatile combustible matter to fixed carbon	1:1·90

It yields, by fast coking, a firm coherent coke. The gases evolved during coking burn with a yellow luminous smoky flame. Colour of the ash, white with a faint reddish tinge. The same becomes slightly agglutinated at a bright red heat, and at a most intense red heat it becomes fritted.

113.—Coal. From a seam at the head of Snow creek, between Panther and Red Deer rivers, Alta. Thickness of seam, five feet. Collected by Mr. D. B. Dowling.

An analysis, by fast coking, afforded Mr. F. G. Wait:

Hygroscopic water	0·72
Volatile combustible matter	21·28
Fixed carbon	75·80
Ash	2·20
	100·00
Coke, per cent	78·00
Ratio of volatile combustible matter to fixed carbon	1:3·56

It yields, by fast coking, a compact, firm, coherent coke. Colour of the ash, white. It imparts a pale brownish-yellow colour to a boiling solution of caustic potash.

114.—Coal. From Millers workings on the Lewes river, Ykn., about twenty miles above Five Finger rapids. Geological position—Cretaceous. Collected by Mr. R. G. McConnell.

Structure, lamellar—made up of a greyish-black, dull, and bright black coal; shows slickensides; slightly soils the fingers; is hard and firm; fracture, irregular; is, here and there, intersected by a few films of calcite; powder, blackish-brown; it communicates a barely perceptible colour to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by fast coking, gave :

Hygroscopic water	0·45
Volatile combustible matter	28·74
Fixed carbon	56·74
Ash	14·07
	100·00
Coke, per cent	70·81
Ratio of volatile combustible matter to fixed carbon	1:1·97

It yields, by fast coking, a compact, firm, coherent coke. The gases evolved during coking burn with a yellow, luminous, smoky flame. Colour of the ash, white with a faint reddish-brown tinge. The same, at a bright red heat becomes slightly agglutinated, whilst at a most intense red heat it undergoes incipient fusion.

115.—Coal. From tunnel on lower seam at Coal gully, on the west side of the Coldwater, a mile and a half south of the confluence of the Coldwater and Nicola rivers, Yale dist., B.C. Thickness of seam, thirteen feet six inches. Geological position—Tertiary. This, and the following specimen were collected by Dr. R. W. Ells.

Structure, somewhat coarse lamellar—made up of irregularly alternating layers of a greyish-black, feebly lustrous, and dense, velvet-black, highly lustrous coal ; fracture, on the whole, uneven, that of the denser layers sub-conchoidal ; it is, here and there, intersected by thin plates of calcite ; contains numerous particles of a pale brownish-yellow to reddish-brown, sub-transparent resin diffused through its substance ; is hard and firm ; does not soil the fingers ; colour of powder, brownish-black ; it communicates a faint brownish-yellow colour to a boiling solution of caustic potash ; resists—does not become fissured or disintegrated—exposure to the air.

An analysis, by fast coking, gave :

Hygroscopic water	3·04
Volatile combustible matter	37·18
Fixed carbon	52·05
Ash	7·73
	100·00
Coke, per cent	59·78
Ratio of volatile combustible matter to fixed carbon	1:1·40

It yields, by fast coking, a compact, firm, coherent coke. Colour of the ash, reddish-white.

116.—Coal. From the southerly or upper outcrop of a seam on the bank of the Coldwater, about two miles south of its confluence with the Nicola, Yale dist., B.C. Thickness of seam, seven feet ten inches. Geological position—Tertiary.

Structure, on the whole, fine lamellar,—compact, made up of layers of a faint greyish-black, somewhat dull, and velvet-black, lustrous coal; fracture, uneven, that of the bright layers sub-conchoidal; is hard and firm; does not soil the fingers; colour of powder, brownish-black; it communicates a brownish-yellow colour to a boiling solution of caustic potash; it apparently resists—does not become fissured or disintegrated—exposure to the air.

An analysis, by fast coking, gave:

Hygroscopic water	3·17
Volatile combustible matter	35·73
Fixed carbon	55·25
Ash	5·85
	100·00
Coke, per cent.	61·10
Ratio of volatile combustible matter to fixed carbon	1:1·55

It yields, by fast coking, a firm coherent coke. Colour of the ash, light reddish-brown.

117.—Coal. From the northerly or lower outcrop of the seam referred to under the preceding specimen, but about a mile and three-quarters south of the confluence of the Coldwater with the Nicola. Thickness of seam, seven feet six inches. Geological position—Tertiary. Examined for Mr. C. H. Keefer.

Structure, very fine lamellar—compact; colour, velvet-black; lustre, for the most part sub-resinous to resinous, at times vitreous; fracture, uneven; does not soil the fingers, except in parts containing a thin film of mineral-charcoal; is hard and firm; colour of powder, brownish-black; it communicates only a just perceptible brownish-yellow tinge to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by fast coking, gave:

Hygroscopic water	1·37
Volatile combustible matter	38·24
Fixed carbon	54·25
Ash	6·14
	100·00
Coke, per cent	60·39
Ratio of volatile combustible matter to fixed carbon	1:1·42

It yields, by fast coking, a compact, firm, coherent coke. Colour of the ash, light reddish-brown.

118.—Coal. From a seam on the east fork of Pine river (south)—a tributary of Peace river, B.C. Geological position—Cretaceous, Dunvegan series. This, and the two following specimens were collected by the late Mr. Arthur Webster, who informed me that the seams from which they were taken ranged from eight to twelve inches in thickness.

Structure, fine lamellar—compact; colour, black; lustre, resinous; fracture, uneven; is hard and firm; does not soil the fingers; powder, brownish-black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	1·70
Volatile combustible matter	43·76
Fixed carbon	50·10
Ash	4·44
	100·00
Coke, per cent	54·54
Ratio of volatile combustible matter to fixed carbon	1:1·14

It yields, by fast coking, a compact, firm, coherent coke. Colour of the ash, light reddish-brown.

119.—Coal. From a seam on Cañon creek, Pine river (south,)—a tributary of Peace river, B.C. Geological position—Cretaceous, Dunvegan series.

Structure, somewhat fine lamellar—compact; colour, greyish black; lustre, sub-resinous to resinous; fracture, uneven; is hard and firm; powder, greyish-black; it communicates a

faint brownish-yellow colour to a boiling solution of caustic potash.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	0·67
Volatile combustible matter	17·23
Fixed carbon	77·34
Ash	4·76
	100·00
Coke, per cent	82·10
Ratio of volatile combustible matter to fixed carbon	1:4·49

It yields, by fast coking, a coherent but tender coke, which on incineration leaves a white ash.

120.—Coal. From a seam on Coal brook, Pine river (south),—a tributary of Peace river, B.C. Geological position—Cretaceous, Dunvegan series.

Structure, somewhat fine lamellar—compact, made up of layers of a greyish-black, dull, and bright black coal; lustre, sub-resinous to resinous; fracture, uneven; powder, brownish-black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	1·39
Volatile combustible matter	23·11
Fixed carbon	31·38
Ash	44·12
	100·00
Coke, per cent	75·50
Ratio of volatile combustible matter to fixed carbon	1:1·36

It yields, by fast coking, a firm coherent coke; and, on incineration, leaves a very light reddish-brown ash.

The above sample of this coal contained some interposed layers of shale. These were not separated from the coal at the time of preparing the material for analysis, inasmuch as a wish had been expressed that this should be conducted upon a fair average sample of the whole, as sent. Hence, the large percentage of ash shown in the analysis.

It may be mentioned, in connexion with the last three above referred to samples of fuel, that the occurrence of coal on Pine river was noted by Dr. A. R. C. Selwyn in the course of his exploration of that stream in August 1875, —See Report of Progress, 1875-76, pp. 28-86. In this he mentions, on p. 53, having found on Pine river, five miles above the Lower forks, four thin seams of good bright coal in about ninety feet of alternating beds of sandstone and shale. These coal seams being, in descending order, six inches, eight inches, two feet, and six inches thick. A sample of the material of the two-foot seam was collected by Dr. Selwyn and submitted to the writer for examination, with the following results:

Structure, very fine lamellar, the lines of bedding, which are very numerous and close together, are frequently very indistinct or altogether obliterated,—compact; colour, black; lustre of fracture parallel to the bedding dull, that of the cross fracture resinous, occasionally brilliant; hard and firm; fracture, uneven; contains a brownish yellow sub-transparent resin, chiefly in small particles, diffused through its substance; powder, very dark brown, inclining to blackish-brown; it communicates only a just perceptible brownish-yellow tinge to a boiling solution of caustic potash; resists exposure to the air. In appearance it is not unlike some varieties of coal of the Carboniferous system.

An analysis, by fast coking, gave:

Hygroscopic water	2·45
Volatile combustible matter	33·76
Fixed carbon	48·69
Ash	15·10
	100·00
Coke, per cent	63·79
Ratio of volatile combustible matter to fixed carbon	1:1·44

It yields, by fast coking, a firm, compact, and lustrous coke, the coking being doubtless materially influenced by the presence of the resin. Colour of the ash, white. This, when exposed to a bright red heat does not become agglutinated, but at a most intense red heat it becomes slightly sintered.

Again, and in the same connexion, Dr. G. M. Dawson mentions on page 117 of his Report, Pt. B, for 1879-80, that on the lower part of Coal brook, coal was discovered by Mr. J. Hunter

in 1877, as is mentioned by him in the C.P.R'y. Report of 1878, p. 79. Dr. Dawson personally examined this locality, which is two miles and a half east of the lower forks, in 1879, and found that the coal occurs in several beds and appears to be of good quality, but so far as observed all are very thin, the thickest not exceeding six inches. He collected, and handed me, a sample of the material from the six-inch bed in question, and the following are the results of its examination :

Structure, very fine lamellar, the lines of bedding, which are very numerous and close together, are almost obliterated,—compact; colour, black; lustre, sub-resinous to resinous, occasionally, in parts, brilliant; hard and firm; shows well-defined planes of cleat; does not soil the fingers; weathered surfaces in places coated with ferric hydrate; powder, brownish-black; it communicates a deep brownish-red colour to a boiling solution of caustic potash; resists exposure to the air; in appearance it resembles some varieties of coal of the Carboniferous system.

An analysis, by fast coking, gave :

Hygroscopic water	7·83
Volatile combustible matter	34·21
Fixed carbon	52·09
Ash	5·87
	100·00
Coke, per cent	57·96
Ratio of volatile combustible matter to fixed carbon.	1:1·52

It yields, by fast coking, a non-coherent coke. The ash has a reddish-white colour; exposed to a bright red heat it becomes very slightly agglutinated, and at a most intense red heat it becomes slightly fritted.

121.—Anthracitic coal.—From Sheep creek, close on line between sections 19 and 30, township 19, range V, west of the fifth initial meridian, Alta.

A compact, greyish-black, almost lustreless coal, traversed by occasional very thin seams of velvet-black, highly lustrous material; fracture, on the whole, uneven, that of the bright layers, conchoidal; does not soil the fingers; is tough, and more or less sonorous; readily takes fire in a lamp flame, burn-

ing with a yellow luminous flame, which, however, dies out immediately after withdrawal from the source of heat; colour of powder, brownish-black; it does not impart any colour to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by fast coking, gave:

Hygroscopic water	0·53
Volatile combustible matter	14·99
Fixed carbon	64·55
Ash	19·93
	100·00
Coke, per cent	84·48
Ratio of volatile combustible matter to fixed carbon	1:4·31

It yields, by fast coking, a compact, firm, coherent coke. The gases evolved during coking burn with a yellow, luminous, somewhat smoky flame. Colour of the ash, white. This, at a bright red heat, becomes very slightly agglutinated, and at a most intense red-heat, slightly fritted.

122.—Anthracitic coal. From No. 4 seam at the Canmore mine, northwest quarter of section 29, tp. 24, range X, west of the fifth initial meridian, Alta. Seam, three feet one inch thick.

Structure, coarse lamellar, moderately compact; shows jointage planes, and evidence of slickensiding, in an eminent degree; contains an occasional thin layer of mineral charcoal; colour, velvet black; lustre, sub-metallic, almost metallic; in parts iridescent; fracture, on the whole, uneven, that of the individual layers, sub-conchoidal to conchoidal; powder, black; it imparts only a just perceptible yellowish tinge to a boiling solution of caustic potash.

An analysis, by fast coking, gave:

Hygroscopic water	0·72
Volatile combustible matter	15·73
Fixed carbon	80·90
Ash	2·65
	100·00
Coke, per cent	83·55
Ratio of volatile combustible matter to fixed carbon	1:5·14

It yields, by fast coking, a compact, firm, coherent coke. The gases evolved during coking burn with a yellow, luminous, somewhat smoky flame. Colour of the ash, white with a faint reddish tinge. At a bright red heat, the ash becomes agglutinated, and at a most intense red heat, slightly fritted.

123.—Anthracitic coal. From pinch-out northwest of slope, bottom of No. 1 seam at the Canmore mine, Alta. This, and the following specimen, was collected by Mr. D. B. Dowling.

Structure, compact, highly contorted, shows slickensides in an eminent degree; is mostly made up of layers of a dense, velvet-black, highly lustrous coal, with a few interposed layers of a greyish-black, comparatively dull coal; does not soil the fingers; is brittle; fracture, on the whole, uneven, that of the denser layers, imperfectly conchoidal; powder, black with a faint brownish tinge; does not impart the least colour to a boiling solution of caustic potash; is hard and firm; resists exposure to the air.

An analysis, by fast coking, gave:

Hygroscopic water	0·43
Volatile combustible matter	15·10
Fixed carbon	81·74
Ash	2·73
	100·00
Coke, per cent	84·47
Ratio of volatile combustible matter to fixed carbon	1:5·41

It yields, by fast coking, a compact, firm, coherent coke. The gases evolved during coking burn with a yellow, luminous flame. Colour of the ash, white with a very faint reddish tinge. At a bright red heat the ash becomes very slightly agglutinated, and at a most intense red heat it becomes slightly fritted.

124.—Anthracitic coal. The material examined was in the form of more or less rounded fragments, found loose in the dry bed of a gully, but which had evidently become detached from a vertical seam occurring high up the mountain on the east branch of Kananaskis river,—a tributary of the Bow, five miles below the head of Elbow river, section 33, tp. 19, range VIII, Alta

Structure, fine lamellar, the line of bedding is, however, frequently indistinct, — compact; colour, greyish-black to black; lustre, dull to resinous; hard and firm; fracture, uneven; powder, black with a slight brownish tinge; it communicates a faint brownish-yellow colour to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by fast coking, gave:

Hygroscopic water	0·87
Volatile combustible matter	13·66
Fixed carbon	66·72
Ash	18·75
	100·00
Coke, per cent	85·47
Ratio of volatile combustible matter to fixed carbon	1:4·88

It yields, by fast coking, a slightly fritted coke. The gases evolved during coking burn with a yellow, luminous, very slightly smoky flame. Colour of the ash, white with a faint reddish tinge. At a bright red heat, the ash becomes very slightly agglutinated, and at a most intense red heat, fritted.

125.—Anthracitic coal. From the Costigan seam, three miles west of the forks of Panther river, Alta. Thickness of seam, five feet seven inches. Collected by Mr. D. B. Dowling.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	0·69
Volatile combustible matter	15·75
Fixed carbon	77·15
Ash	6·41
	100·00
Coke, per cent	83·56
Ratio of volatile combustible matter to fixed carbon	1:4.90

It yields, by fast coking, a firm, coherent coke. Colour of the ash, white. The powder imparts a very faint brownish-yellow colour to a boiling solution of caustic potash.

126.—Anthracitic coal. From seam one hundred and sixty-four feet below that of the preceding specimen. Thickness of seam, three feet six inches. Collected by Mr. D. B. Dowling.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	0·79
Volatile combustible matter	15·66
Fixed carbon	76·05
Ash	7·50
	100·00
Coke, per cent	83·55
Ratio of volatile combustible matter to fixed carbon.	1:4·86

It yields, by fast coking, a feebly coherent coke. Colour of the ash, white. Its powder imparts a faint brownish-yellow colour to a boiling solution of caustic potash.

127.—Anthracitic coal. From a seam two hundred and seventy feet below the Costigan seam,—see above—No. 125, Panther river. Thickness of seam, three feet six inches. Collected by Mr. D. B. Dowling.

An analysis by Mr. Wait, by fast coking, gave:

Hygroscopic water	0·61
Volatile combustible matter	16·49
Fixed carbon	79·56
Ash	3·34
	100·00
Coke, per cent.	82·90
Ratio of volatile combustible matter to fixed carbon.	1: 4·82

It yields, by fast coking, a firm, coherent coke. Colour of the ash, white. Its powder imparts a scarcely perceptible coloration to a boiling solution of caustic potash.

128.—Semi-anthracite. From C. P. R. tunnels, Cascade mountain, section 19, tp. 26, range XI, Alta. Collected by Mr. D. B. Dowling.

Structure, compact, highly contorted, shows slickensides in an eminent degree; is made up of alternating layers of a greyish-black, somewhat bright, and dense, jet-black coal of brilliant lustre; hard and firm; fracture, uneven, that of the denser and more lustrous layers often more or less conchoidal; powder black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash; resists exposure to the air; does not decrepitate when suddenly heated.

An analysis, by fast coking, gave :

Hygroscopic water	0·43
Volatile combustible matter	10·65
Fixed carbon	85·02
Ash	3·90
	100·00
Coke, per cent	88·92
Ratio of volatile combustible matter to fixed carbon.	1: 7·98

It yields, by fast coking, a non-coherent coke. When heated in a covered crucible it yields a small amount of gas, which burns with a pale yellowish, feebly luminous flame. Colour of the ash white; the same when exposed to a bright red heat becomes very slightly agglutinated, and at a most intense red heat it becomes fritted.

129.—SEMI-ANTHRACITE. From a seam on the south branch of Sheep creek, section 11, tp. 19, range VII, Alta. The seam has a thickness of nine feet, but of this, the upper three feet is very much shattered and readily falls to pieces; the lower six feet, however, consists of a fairly firm coal. Collected by Mr. D. B. Dowling.

The material of the lower six feet of this seam answers to the following description :—Structure, coarse lamellar, compact, made up of irregularly alternating layers of a greyish-black, for the most part dull, and dense, jet-black, highly lustrous coal; with an occasional thin, interposed layer of mineral charcoal; shows slickensides; is hard and firm; brittle; fracture, on the whole, irregular, that of the denser layers sub-conchoidal; powder, black; it does not impart a colour to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by fast coking, gave :—

Hygroscopic water	1·30
Volatile combustible matter	11·14
Fixed carbon	77·13
Ash	10·43
	100·00
Coke, per cent	87·56
Ratio of volatile combustible matter to fixed carbon.	1: 6·92

It yields, by fast coking, a non-coherent coke. When heated in a covered crucible it yields a small amount of gas, which burns with a pale yellowish, smokeless flame of feeble luminosity. On incineration it leaves a white ash. This does not agglutinate at a bright red, or even a most intense red, heat.

130.—SEMI-ANTHRACITE. From the Costigan seam, at its outcrop just above the forks of Panther river, Alta. Thickness of seam, four feet four and a half inches. Collected by Mr. D. B. Dowling.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	1·14
Volatile combustible matter	13·63
Fixed carbon	80·64
Ash	4·59
	100·00
Coke, per cent	85·23
Ratio of volatile combustible matter to fixed carbon.	1 : 5·92

It yields, by fast coking, a non-coherent coke. Colour of the ash, white, with a faint reddish tinge. Its powder imparts a very pale brownish-yellow colour to a boiling solution of caustic potash.

131.—SEMI-ANTHRACITE. From an exposure nine miles and a half west of the outcrop of the seam last referred to. Thickness of seam, two feet. Collected by Mr. D. B. Dowling.

An analysis by Mr. Wait, by fast coking, gave:

Hygroscopic water	1·13
Volatile combustible matter	11·59
Fixed carbon	84·94
Ash	2·34
	100·00
Coke, per cent	87·28
Ratio of volatile combustible matter to fixed carbon.	1 : 7·33

It yields, by fast coking, a non-coherent coke. Colour of the ash, white. Its powder imparts a pale brownish-yellow colour to a boiling solution of caustic potash.

132.—SEMI-ANTHRACITE. From a five-foot seam occurring above that from which the preceding specimen was taken. Collected by Mr. D. B. Dowling.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	0·93
Volatile combustible matter	10·58
Fixed carbon	83·55
Ash	4·94
	100·00
Coke, per cent	88·49
Ratio of volatile combustible matter to fixed carbon.	1 : 7·90

It yields, by fast coking, a non-coherent coke. Colour of the ash, white. Its powder imparts a very pale brownish-yellow colour to a boiling solution of caustic potash.

133.—SEMI-ANTHRACITE. From lower seam on Goat creek—a tributary of Telkwa river, which flows into Bulkley river, Cassiar dist., B.C. Thickness of seam, about fourteen feet. Received from Mr. G. H. Cowan.

Structure, compact,—lines of bedding not always very distinct; it contains a few layers of interstratified bright black coal; colour light-greyish black; lustre, sub-resinous to resinous; fracture, uneven, that of the bright layers conchoidal; is hard and firm; does not soil the fingers; powder, almost black; imparts no colour to a boiling solution of caustic potash; resists exposure to the air.

An analysis, by Mr. Wait, by fast coking, gave:

Hygroscopic water	0·98
Volatile combustible matter	9·94
Fixed carbon	80·76
Ash	8·32
	100·00
Coke, per cent	89·08
Ratio of volatile combustible matter to fixed carbon.	1 : 8·12

It yields, by fast coking, a non-coherent coke. Colour of the ash, white.

LIMESTONES AND DOLOMITES.

[Continued from page 28 R of the Annual Report—vol. xiii, 1900.]

1.—LIMESTONE. From an extensive deposit of the same immediately east of the end of the bar at the mouth of South pond of Aspy bay, Victoria co., N.S. Geological position—Lower Carboniferous. Collected by Mr. Hugh Fletcher.

A light bluish to light brownish-grey, very fine-crystalline, in parts vesicular, fossiliferous limestone.

An analysis, by Mr. F. G. Wait, of a fair average sample of this stone—prepared from equal weights of thirty-three fragments of the same taken from as many different parts of the deposit, showed it to have the following composition:

(After drying at 100°C.—Hygroscopic water=0·08 per cent.)

Calcium carbonate			95·95
Magnesium carbonate			0·29
Ferrous carbonate			0·17
Manganous carbonate			0·34
Calcium sulphate		0·25	
Calcium phosphate		0·01	
Alumina		0·01	
Silica, soluble		0·02	
Organic matter		0·40	3·57
Insoluble matter, consisting of:			
Silica	2·43		
Alumina	0·27		
Ferric oxide	0·09	2·88	
Lime	0·02		
Magnesia	0·01		
Alkalies, by difference	0·06		
			100·32

2.—LIMESTONE. From an extensive deposit at Dewar hill, west side of Pugwash harbour, Cumberland co., N.S. Geological position—Lower Carboniferous. Collected by Mr. Hugh Fletcher.

A light grey—at times, ash-grey, brownish-grey, and reddish-grey very fine-granular to almost compact, fossiliferous limestone.

An analysis, by Mr. Wait, of a fair average sample of this stone—prepared from equal weights of twenty-five fragments

of the same taken from equidistant points across the strike of a series of nearly vertical beds having, in the quarry worked, a total thickness of sixty feet, afforded the following results:

(After drying at 100°C.—Hygroscopic water=0.12 per cent.)

Calcium carbonate			76·98
Magnesium carbonate			12·05
Ferrous carbonate			0·50
Manganous carbonate			0·53
Calcium sulphate		0·14	
Calcium phosphate		0·04	
Alumina		0·21	
Silica, soluble		0·15	
Organic matter		0·41	10·06
Insoluble matter, consisting of:			
Silica	6·70		
Alumina	1·49		
Ferric oxide	0·27	9·11	
Lime	0·03		
Magnesia	0·15		
Alkalies, by difference	0·47		
			100·12

3.—Limestone. From a deposit three miles east of Brookfield station on the line of the Intercolonial railway, Colchester, co., N.S. Geological position—Windsor formation, Lower Carboniferous. Collected by Dr. H. M. Ami.

An ashy-brown fossiliferous limestone, the composition of which was found by Mr. Wait to be as follows:

(After drying at 100°C—Hygroscopic water=0.18 per cent.)

Calcium carbonate			97·97
Magnesium carbonate			1·22
Ferrous carbonate			0·13
Manganous carbonate			0·16
Calcium sulphate		0·17	
Calcium phosphate		0·06	
Alumina		0·02	
Silica, soluble		0·02	
Organic matter		0·17	0·61
Insoluble matter, consisting of:			
Silica	0·09		
Alumina with a little ferric oxide	0·06	0·17	
Lime	0·01		
Magnesia	0·01		
			100·09

4.—Limestone. From the quarry of Mr. B. Beaulieu, on Little Mascouche road, Ste. Anne des Plaines par., Terrebonne co., Que.

A dark greyish, fine to somewhat coarse-crystalline, fossiliferous, limestone. An analysis by Mr. Wait, showed it to have the following composition:

(After drying at 100° C.—Hygroscopic water = 0·08 per cent.)

Calcium carbonate			97·46
Magnesium carbonate			1·76
Ferrous carbonate			0·03
Manganous carbonate			trace.
Calcium sulphate		trace.	
Calcium phosphate		0·11	
Alumina		0·03	
Silica, soluble		0·03	
Organic matter		0·18	1·04
Insoluble matter, consisting of:			
Silica	0·45		
Alumina	0·12		
Ferric oxide	0·08	0·69	
Lime	0·01		
Magnesia	0·01		
Alkalies, by difference	0·02		
			100·29

5.—Limestone. From Carswell's quarry, lot 13, range I, Litchfield tp., Pontiac co., Que. Geological position—Grenville series —Huronian. Collected by Mr. R. L. Broadbent.

A light to rather dark bluish-grey, moderately coarse-crystalline limestone, through which are distributed a few particles of quartz, hornblende, and pyrrhotite. Its composition was found, by Mr. Wait, to be as follows:

(After drying at 100° C.—Hygroscopic water = 0.05 per cent.)

Calcium carbonate			89·03
Magnesium carbonate			8·70
Ferrous carbonate			0·07
Manganous carbonate			trace.
Calcium phosphate		0·01	
Alumina		0·17	
Silica, soluble		0·49	
Iron sulphide, pyrrhotite		0·09	
Organic matter		0·10	2·21
Insoluble matter, consisting of:			
Silica	0·77		
Alumina with a trace of ferric oxide	0·15	1·35	
Lime	trace.		
Magnesia	0·43		
			100·01

6.—Limestone. From the immediate vicinity of Philipsburg, on the east side of Missisquoi lake, Armand tp., Missisquoi co., Que. Geological position—Philipsburg formation, Quebec group, Lower Silurian.

An exceedingly fine-crystalline, almost compact, limestone of a dove-grey colour with white markings. Its analysis afforded Mr. Wait the following results:

(After drying at 100° C.—Hygroscopic water = 0·02 per cent.)

Calcium carbonate			98·03
Magnesium carbonate			0·97
Ferrous carbonate			0·07
Calcium phosphate		0·01	
Alumina		0·01	
Silica, soluble		0·03	
Organic matter		0·06	1·52
Insoluble matter, consisting of:			
Silica	1·14		
Alumina with a little ferric oxide	0·19	1·41	
Lime	0·06		
Magnesia	0·02		
			100·59

This stone takes a good polish and is well fitted for purposes of decoration. When burnt it affords a very white and pure lime.

7.—Limestone. From Rudd's quarry, Barriefield, Pittsburg tp., Frontenac co., Ont.

A light bluish-grey, very fine crystalline, massive, magnesian limestone. Determinations, by Mr. Wait, of the more important constituents, gave, as follows:

Calcium carbonate	49·8
Magnesium carbonate	25·2
Alumina with a little ferric oxide	2·1
Insoluble matter	22·0

The insoluble portion of this stone consisted of—silica 13·24, alumina with a little ferric oxide 4·04, small quantities of lime and magnesia, and strong traces of alkalies.

8.—Limestone. From Marble cove, on the northeast shore of Texada island, Strait of Georgia, B. C. Geological position—Carboniferous.

A somewhat fine crystalline limestone of a light and dark bluish-ash colour, clouded, with greyish-black spots and veinings. An analysis by Mr. Wait showed it to have the following composition :

(After drying at 100° C.—Hygroscopic water = 0·01 per cent.)

Calcium carbonate			87·01
Magnesium carbonate			12·47
Ferrous carbonate			0·34
Manganous carbonate			trace.
Calcium phosphate		0·01	
Alumina		0·02	
Silica, soluble		0·11	
Organic matter		0·15	0·64
Insoluble matter, consisting of :			
Silica	0·20		
Alumina with a little ferric oxide	0·08	0·35	
Lime	0·01		
Magnesia	0·06		
			100·46

This stone occurs, at the above mentioned locality, in almost unlimited quantity. It is useful for ordinary purposes of contruction and, taking a good polish, is also well adapted for use as a marble. Further, it affords an excellent material for the manufacture of lime.

9.—DOLOMITE. From lot 2, con. 11, Faraday tp., near the old Faraday road, Hasting co., Ont. The bed from which this stone was taken, a very large one, extends into the adjoining lot, lot 3, of the same concession where, however, according to Mr. C. W. Willimott, the stone exhibits a much coarser texture.

A faint greenish-white to greyish-white, cryptocrystalline, sub-translucent, magnesian limestone. Its composition was found by Mr. Wait to be as follows :

(After drying at 100° C.—Hygroscopic water = 0·02 per cent.)

Calcium carbonate			55·22
Magnesium carbonate			44·03
Ferrous carbonate			0·26
Manganous carbonate			0·11
Calcium phosphate		trace	
Alumina		0·04	
Silica, soluble		0·03	
Insoluble matter, consisting of :			0·74
Silica	0·39		
Alumina with a trace of iron	0·15	0·67	
Magnesia	0·13		
			100·36

This stone takes a very high polish and affords an excellent marble.

IRON ORES.

1.—CLAY IRON-STONE. A compact, massive, dark brownish-grey, lustreless, clay iron-stone, very tough, and breaking with a large conchoidal fracture, from section 17, tp. 10, range XXI, west of the fourth initial meridian, Alta., has been analysed by Mr. F. G. Wait, and found to have the following composition :

Ferrous oxide	44·87
Manganous oxide	1·54
Alumina	4·25
Lime	4·80
Magnesia	1·67
Carbonic anhydride	33·57
Phosphoric anhydride	0·43
Sulphuric anhydride	0·02
Silica	7·56
Iron disulphide	0·09
Water	0·62
Organic matter	1·29
	100·71
Metallic iron	34·94
Phosphorus	0·19
Sulphur	0·06

Mr. Wait has also examined a specimen of a dark grey, very fine-granular, almost compact, clay iron-stone, upon one of the surfaces of which were implanted numerous small crystals of selenite, from section 6 of the above mentioned township, and found it to contain—ferrous oxide 42·56 per cent, equivalent to 33·10 per cent of metallic iron.

Among the many specimens of clay iron-stone collected by Dr. G. M. Dawson at the time of his exploration of the Bow and Belly River region, in 1881, were three from points not far distant from those where the foregoing were obtained. These were examined by the writer, and the results of their analysis were given in the Annual Report of this Survey for 1880-81-82, p. 11 H. They comprised, (a) a specimen of a very fine-granular massive brownish-grey, clay iron-stone, breaking with an imperfectly conchoidal fracture, from "Coal Banks," which was found to contain—ferrous oxide 41·458 and ferric oxide 0·328 per cent, equivalent to a total of 32·475 per cent of metallic iron ; (b) a specimen of a fine-granular, massive, pale reddish-brown clay iron-stone, breaking with an irregular fracture, from about

seven miles below "Coal Banks," Alta., section 30, tp. 9, range XXI, west of the fourth initial meridian, which was found to contain—ferrous oxide 30·730 and ferric oxide 1·398 per cent, equivalent to a total of 24·880 per cent of metallic iron; and (c) a specimen of a compact, massive, pale brownish-yellow clay iron-stone, breaking with a large conchoidal fracture, from Belly river, about seventeen miles east of the mouth of the Little Bow river, section 19, tp. 10, range XVI, west of the fourth initial meridian, Alta., which was found to contain—ferrous oxide 30·302 and ferric oxide 1·487 per cent, equivalent to a total of 26·165 per cent of metallic iron.

2.—Clay iron-stone. A dark clove-brown, very fine granular, almost compact, massive, clay iron-stone from Collin gulch; Tulameen river, about eighteen or twenty miles west of Princeton, Yale dist., B.C., has been examined by Mr. F. G. Wait, and found to contain:

Ferrous oxide	27·05	per cent.
Ferric oxide	1·37	"
Insoluble siliceous matter	46·11	"
Carbonaceous matter	1·82	"
Water, hygroscopic	0·19	"
Metallic irons	22·00	"

This iron-stone occurs in bands, having an aggregate thickness of some three feet, in the so-called twenty-foot seam of coal at the locality above mentioned. An analysis of the coal of the seam in question is given in one of my previous reports, —see Annual Report, vol. 12, p. 29 R, 1899.

3.—Bog-iron ore. The following are the results of an analysis, by Mr. F. G. Wait, of a fair average sample prepared from equal weights of numerous fragments of bog-iron ore taken from a series of isolated deposits of that mineral occurring in a strip of country—overlying the black slates of the Nova Scotian gold-bearing series—of some forty miles in length by about two miles in width, which extends, in a southwesterly direction, from Upper Musquodoboit along the south side of the Musquodoboit river and along the south side of the old Guysborough road to Fall river, Halifax co., N.S.

It was found to contain:

Ferric oxide	64·04
Ferrous oxide	9·27
Manganous oxide	2·14
Alumina	0·68
Lime	1·55
Magnesia	0·68
Silica	5·65
Phosphoric anhydride	0·04
Sulphuric anhydride	0·30
Water, hygroscopic	3·37
Water, combined	10·53
Organic matter	3·22
	101·47
Metallic iron	52·04
Phosphorus	0·02
Sulphur	0·12

The following partial analyses of hematites and magnetites were all conducted by Mr. F. G. Wait.

4.—Hematite. From about half a mile south of Grand Pré (Lower Horton) Railway station, Kings co., N.S. Collected by Mr. A. T. McKinnon.

A reddish-brown to brownish-red, fine-granular, massive admixture of anhydrous and hydrous peroxide of iron. It contained—metallic iron 47·40 per cent, insoluble residue 24·16, water, hygroscopic, 0·90 and water, combined, 4·59. Titanium dioxide, none.

5.—Hematite. From lot 1, range III, Dunham tp., Missisquoi co., Que. Examined for Mr. Levi. Y. Blake.

A dark purplish-brownish-red, very fine granular, almost compact, schistose, massive hematite. It was found to contain—metallic iron, 62·71 per cent, insoluble residue 6·90, titanium dioxide, none.

6.—Hematite. From the Rocky mountains, south of Blairmore, Alta.

A fine granular, massive, in parts micaceous, hematite, through which was distributed a few particles of iron-pyrites. Determinations gave—metallic iron, 68·51 per cent, insoluble siliceous matter, 2·01, titanium dioxide, none.

7.—Magnetite. From the property of W. R. Neily, and close to the Leckie mine, Torbrook mines, Annapolis co., N.S.

A fine to somewhat coarse-granular, massive magnetite, through which was distributed a somewhat large quantity of quartzose gangue. It contained—metallic iron 51·92 per cent, insoluble siliceous matter 24·03, titanium dioxide, none.

8. -Magnetite. From Clarendon par., Charlotte co., N.B. Received from John Shearer.

A fine crystalline granular, massive magnetite, through which was distributed a small quantity of quartzose gangue. Analysis showed it to contain—metallic ore, 65·42 per cent insoluble siliceous matter, 9·36, titanium dioxide, none.

9.—Magnetite. From the northwest branch of the Gatineau river, Que.

A moderately fine-crystalline, massive magnetite holding a large quantity of intermixed gangue composed, for the most part, of hornblende. It was found to contain—metallic iron 45·81 per cent, insoluble matter 33·90, titanium dioxide, none.

10.—Magnetite. From a point on the Rivière des Quinze (Ottawa river), Lake Timiskaming, Que.

A fine-crystalline, massive, schistose magnetite, with which was associated a somewhat large quantity of siliceous gangue. Determinations gave—Metallic iron 52·40 per cent, insoluble siliceous matter 26·60, titanium dioxide, none.

11.—Magnetite. From lot 27, con. 4, North Crosby tp., Lanark co., Ont.

A somewhat coarse-crystalline, massive magnetite with which was intimately associated a large quantity of gangue composed, mainly, of hornblende and feldspar with a little quartz and a few particles of garnet. It contained—Metallic iron 38·97 per cent, insoluble matter 43·30, titanium dioxide, none.

12.—Magnetite. From the vicinity of Lake Temagami, Nipissing dist., Ont.

A very fine-granular, massive magnetite, holding numerous thin laminæ of quartz. It was found to contain—Metallic iron 52·86 per cent, insoluble siliceous matter 24·50, titanium dioxide, none.

13.—MAGNETITE. From a deposit on the east slope of the Rocky mountains, near Pincher creek, Alta.

A fine-granular, massive, partially weathered magnetite. Determinations gave—metallic iron 53·46 per cent, insoluble siliceous matter 14·99, titanium dioxide, none.

14.—MAGNETITE. From near Enderby, Yale dist., B.C.

A fine-crystalline, massive magnetite through which was distributed a small quantity of partially altered feldspathic gangue. Analysis showed it to contain—metallic iron, 59·55 per cent, insoluble matter 12·85, titanium dioxide, traces.

COPPER ORES.

1.—From a shaft sunk in the Triassic trap at Westport, Digby co., N.S.

A partially altered trap through which was scattered a small quantity of native copper. Agreeably with the results of a determination made by Mr. Wait, it contained :

Copper.... .. .. 00·19 per cent

2.—From La Tête, Charlotte co., N.B.

An association of copper-pyrites and iron-pyrites, with a little pyrrhotite, in a gangue composed for the most part of chloritic schist, with some quartz and calcite and a very little siderite. It was found by Mr. Wait to contain :

Copper .. .. 10.70 per cent.

3.—From Orford tp., Sherbrooke co., Que,

It consisted of chloritic schist carrying small quantities of chalcopyrite and bornite and a very little sphalerite. Mr. Wait found it to contain :

Copper.... ... . 3·12 per cent.

4.—From mining location No. 2961, R. 455, northeast of Schreiber, Thunder Bay dist., Ont.

An association of a dark-grey limestone and calcite with hematite, carrying a small quantity of copper-pyrites and a few flakes of native copper. It was found by Mr. Wait to contain :

Copper	5·07 per cent.

5.—From the Eureka claim No. 14, Britannia mountain, Howe sound, New Westminster dist., B.C.

A dark-grey quartz through which was distributed a small quantity of copper pyrites and a little pyrrhotite. Mr. Wait found it to contain :

Copper	3·83 per cent.

NICKEL AND COBALT.

Estimation of, in certain ores from the undermentioned localities, Ontario and British Columbia. Continued from page 36 R. of the Annual Report (vol. XIII) for 1900.

1.—From the west-half of lot 10, con. 4 Olden tp., Frontenac co., Ont.

An association of quartz and hornblende with a little feldspar, carrying a somewhat small quantity of pyrrhotite and a very little copper-pyrites. The pyrrhotite, freed from the copper-pyrites and all gangue, was found by Mr. Wait to contain.

Nickel	1·92 per cent.
Cobalt	none.

2.—From the north-half of lot 3 of con. 4, Kerns tp., Nipissing dist., Ont.

An association of iron-pyrites and copper-pyrites with small quantities of limonite, hematite, and pyrrhotite, and trifling quantities of erythrite, through which was distributed a small quantity of quartzose gangue. An analysis by Mr. Wait showed it to contain.

Nickel	0·11 per cent.
Cobalt	1·68 "
Copper	6·07 "

3.—From near Ingall station on the line of the Canadian Pacific railway, some thirty miles west of Rat Portage, Rainy River dist., Ont. Collected by Dr. R. Bell.

A compact, massive pyrrhotite. It was found by Mr. Wait to contain:

Nickel	none.
Cobalt	none.

4.—From a vein about four miles from Hope and near the Fraser river, Yale dist., B.C.

An association of arsenical-pyrites with a small quantity of iron-pyrites and a very little copper-pyrites, through which was distributed a small quantity of quartzose gangue. The metalliferous portion of the ore, freed from all gangue, was found by Mr. Wait to contain:

Nickel	0·20
Cobalt	trace.

Traces of silver were also shown to be present, but no gold.

NATURAL WATERS.

1.—Water from a spring at Brook village about seven miles east-southeast of Mabou, Inverness co., N. S. It apparently rises from the gypsiferous beds of the Lower Carboniferous. The flow from the spring is constant and estimated to be about four gallons per minute.

The sample received for examination contained a trifling quantity of white flocculent matter in suspension, which was removed by filtration. The filtered water was clear and bright and apparently colourless; when viewed in a column two feet in length, however, it was found to have a just perceptible brownish-yellow hue. It was odourless; had a mildly saline taste; reacted neutral, both before and after concentration; and had a specific gravity, at 15.5° C., of 1008.87. Boiling produced a slight precipitate, consisting of calcium carbonate with a very little magnesium carbonate.

One thousand parts, by weight, of the filtered water, at 15·5° C., were found by Mr. F. G. Wait to contain:

Potassa	0·012
Soda	5·168
Lime	0·575
Magnesia	0·112
Sulphuric anhydride	0·780
Carbonic anhydride	0·134
Chlorine	5·927
Silica	0·013
Organic matter	trace.
	12·721
Less oxygen, equivalent to chlorine	1·336
	11·385

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Potassium chloride	0·019
Sodium chloride	9·752
Calcium sulphate	1·326
Calcium carbonate	0·052
Magnesium carbonate	0·235
Silica	0·013
Organic matter	trace.
	11·397
Less carbonic anhydride employed in excess of that actually found	0·012
	11·385

Total dissolved solid matter, by direct experiment, dried at 180° C., = 11·191

An imperial gallon of the water, at 15·5° C., would contain: (The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

	Grains.
Potassium chloride	1·342
Sodium chloride	688·695
Calcium sulphate	93·643
Calcium carbonate	3·672
Magnesium carbonate	16·596
Silica	0·918
Organic matter	trace
	804·866
Less carbonic anhydride employed in excess of that actually found	0·847
	804·019

Lithia, baryta, strontia, bromine, and iodine were sought for, and with negative results.

2.—Water from a boring on the east bank of the Richelieu river (about one hundred and fifty feet back from that stream and about one hundred feet back from Barbotte creek, which here flows into the Richelieu), on lot 86, con. 1, in St. Athanase par., Bleury seig., Iberville co., Que.

This water had, when first received, a very perceptible greenish-yellow colour, and a pronounced odour of hydrogen sulphide; after standing in a loosely stoppered glass container, however, it became perfectly odourless, colourless, clear and bright. Its specific gravity, at 15·5° C., was found to be 1003.27. Boiling produced a very slight precipitate consisting of calcium carbonate with some magnesium carbonate.

Agreeably with the results of an analysis, conducted by Mr. Wait, one thousand parts, by weight, of this water, at 15·5°C., contained:

Potassa	0·008
Soda	1·632
Lithia	trace.
Lime	0·074
Magnesia	0·139
Ferrous oxide	trace.
Sulphuric anhydride	0·256
Carbonic anhydride	0·290
Chlorine	1·671
Bromine	trace
Iodine (very small quantity)	undet.
Silica	0·012
Hydrogen sulphide	0·026
Organic matter	trace
	4·108
Less oxygen, equivalent to chlorine	0·376
	3·732

The hydrogen sulphide referred to in the above analysis had most probably resulted from the reducing action of organic matter (the water having been put up in an ordinary corked vessel) upon the sulphates present in the water, whereby a certain proportion of these latter were converted into sulphurets which being in turn decomposed by carbonic acid resulted in the separation of hydrogen sulphide.

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination: (The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Potassium sulphate	0·015
Sodium sulphate	0·399
" chloride	2·753
" bromide	trace
" iodide	undet.
Lithium carbonate	trace
Calcium sulphate	0·041
Calcium carbonate	0·102
Magnesium carbonate	0·292
Ferrous carbonate	trace
Silica	0.012
Organic matter	trace
	3·614
Carbonic anhydride, in excess of that required to form monocarbonates	0·092
Hydrogen sulphide, free	0·026
	3·732

Total dissolved solid matter, by direct experiment, dried at 180° C.,–3·579.

The amount of carbonic anhydride found, in excess of that required to form normal carbonates, is somewhat less than half that required by these to form bicarbonates, from which it would appear that only a portion of the neutral carbonates is present in the water in the latter condition.

An imperial gallon of the water at 15·5°C., would contain: (The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

	Grains.
Potassium sulphate	1·053
Sodium sulphate	28·021
" chloride	193·340
" bromide	trace.
" iodide	undet.
Lithium carbonate	trace.
Calcium sulphate	2·879
Calcium carbonate	7·164
Magnesium carbonate	20·507
Ferrous carbonate	trace.
Silica	0·843
Organic matter	trace.
	253·807
Carbonic anhydride, in excess of that required to form monocarbonates	6·461
Hydrogen sulphide, free	1·826
	262·094

Baryta, strontia, and boric anhydride were sought for, and found to be absent.

3.—Water from an artesian-well on the east end of cadastral lot 52, con. 1, St. Johns par., (a mile and a half south of the town of St. Johns, and about thirty feet back from the west shore of the Richelieu river), Longueuil seig., St. Johns co., Que. It was struck at a depth of sixty feet from the surface.

The sample of water sent for examination was, at the time of its receipt, perfectly clear, bright and colourless, but after standing in a loosely stoppered glass container for a few days it deposited a brownish-yellow sediment which, on removal by filtration, was found to consist of ferric hydrate with a very little calcium carbonate. In its original condition this water was perfectly odourless; had a mildly saline taste; reacted neutral, both before and after concentration; and had a specific gravity, at 15·5° C., of 1006·03.

Conformably with the results of an analysis by Mr. Wait, one thousand parts, by weight, of this water, at 15·5° C., contained:

Potassa	0·020
Soda	2·788
Lime	0·265
Magnesia	0·309
Ferrous oxide	0·002
Sulphuric anhydride	1·596
Carbonate anhydride	0·235
Chlorine	2·555
Bromine	trace.
Iodine (very small quantity)	undet.
Silica	0·016
Organic matter	trace.
	7·786
Less oxygen, equivalent to chlorine	0·576
	7·210

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination: (The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Potassium sulphate	0·015
Sodium sulphate	0·399
" chloride	2·753
" bromide	trace
" iodide	undet.
Lithium carbonate	trace
Calcium sulphate	0·041
Calcium carbonate	0·102
Magnesium carbonate	0·292
Ferrous carbonate	trace
Silica	0.012
Organic matter	trace
	3·614
Carbonic anhydride, in excess of that required to form monocarbonates	0·092
Hydrogen sulphide, free	0·026
	3·732

Total dissolved solid matter, by direct experiment, dried at 180° C.,-3·579.

The amount of carbonic anhydride found, in excess of that required to form normal carbonates, is somewhat less than half that required by these to form bicarbonates, from which it would appear that only a portion of the neutral carbonates is present in the water in the latter condition.

An imperial gallon of the water at 15·5°C., would contain: (The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous)

	Grains.
Potassium sulphate	1·053
Sodium sulphate	28·021
" chloride	193·340
" bromide	trace.
" iodide	undet.
Lithium carbonate	trace.
Calcium sulphate	2·879
Calcium carbonate	7·164
Magnesium carbonate	20·507
Ferrous carbonate	trace.
Silica	0·843
Organic matter	trace.
	253·807
Carbonic anhydride, in excess of that required to form monocarbonates	6·461
Hydrogen sulphide, free	1·826
	262·094

Baryta, strontia, and boric anhydride were sought for, and found to be absent.

3.—Water from an artesian-well on the east end of cadastral lot 52, con. 1, St. Johns par., (a mile and a half south of the town of St. Johns, and about thirty feet back from the west shore of the Richelieu river), Longueuil seig., St. Johns co., Que. It was struck at a depth of sixty feet from the surface.

The sample of water sent for examination was, at the time of its receipt, perfectly clear, bright and colourless, but after standing in a loosely stoppered glass container for a few days it deposited a brownish-yellow sediment which, on removal by filtration, was found to consist of ferric hydrate with a very little calcium carbonate. In its original condition this water was perfectly odourless; had a mildly saline taste; reacted neutral, both before and after concentration; and had a specific gravity, at 15·5° C., of 1006·03.

Conformably with the results of an analysis by Mr. Wait, one thousand parts, by weight, of this water, at 15·5° C., contained:

Potassa	0·020
Soda	2·788
Lime	0·265
Magnesia	0·309
Ferrous oxide	0·002
Sulphuric anhydride	1·596
Carbonate anhydride	0·235
Chlorine	2·555
Bromine	trace.
Iodine (very small quantity)	undet.
Silica	0·016
Organic matter	trace.
	7·786
Less oxygen, equivalent to chlorine	0·576
	7·210

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

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Potassium sulphate	0·015
Sodium sulphate	0·399
" chloride	2·753
" bromide	trace
" iodide	undet.
Lithium carbonate	trace
Calcium sulphate	0·041
Calcium carbonate	0·102
Magnesium carbonate	0·292
Ferrous carbonate	trace
Silica	0.012
Organic matter	trace
	3·614
Carbonic anhydride, in excess of that required to form monocarbonates	0·092
Hydrogen sulphide, free	0·026
	3·732

Total dissolved solid matter, by direct experiment, dried at 180° C.,—3·579.

The amount of carbonic anhydride found, in excess of that required to form normal carbonates, is somewhat less than half that required by these to form bicarbonates, from which it would appear that only a portion of the neutral carbonates is present in the water in the latter condition.

An imperial gallon of the water at 15·5°C., would contain: (The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

	Grains.
Potassium sulphate	1·053
Sodium sulphate	28·021
" chloride	193·340
" bromide	trace.
" iodide	undet.
Lithium carbonate	trace.
Calcium sulphate	2·879
Calcium carbonate	7·164
Magnesium carbonate	20·507
Ferrous carbonate	trace.
Silica	0·843
Organic matter	trace.
	253·807
Carbonic anhydride, in excess of that required to form monocarbonates	6·461
Hydrogen sulphide, free	1·826
	262·094

Baryta, strontia, and boric anhydride were sought for, and found to be absent.

3.—Water from an artesian-well on the east end of cadastral lot 52, con. 1, St. Johns par., (a mile and a half south of the town of St. Johns, and about thirty feet back from the west shore of the Richelieu river), Longueuil seig., St. Johns co., Que. It was struck at a depth of sixty feet from the surface.

The sample of water sent for examination was, at the time of its receipt, perfectly clear, bright and colourless, but after standing in a loosely stoppered glass container for a few days it deposited a brownish-yellow sediment which, on removal by filtration, was found to consist of ferric hydrate with a very little calcium carbonate. In its original condition this water was perfectly odourless; had a mildly saline taste; reacted neutral, both before and after concentration; and had a specific gravity, at 15·5° C., of 1006·03.

Conformably with the results of an analysis by Mr. Wait, one thousand parts, by weight, of this water, at 15·5° C., contained:

Potassa	0·020
Soda	2·788
Lime	0·265
Magnesia	0·309
Ferrous oxide	0·002
Sulphuric anhydride	1·596
Carbonate anhydride	0·235
Chlorine	2·555
Bromine	trace.
Iodine (very small quantity)	undet.
Silica	0·016
Organic matter	trace.
	7·786
Less oxygen, equivalent to chlorine	0·576
	7·210

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Potassium sulphate	0·037
Sodium sulphate	1·276
" chloride	4·210
" bromide	trace.
" iodide	strong trace.
Calcium sulphate	0·411
" carbonate	0·171
Magnesium sulphate	0·927
Ferrous carbonate	0·003
Silica	0·016
Organic matter	trace.
	7·051
Carbonic anhydride, half combined	0·077
" " free	0·082
	7·210

Total dissolved solid matters, by direct experiment, dried at 180° C., =7·120

An imperial gallon of the water, at 15·5°C., would contain: (The carbonates being calculated as anhydrous bicarbonates, and the salts without their waters of crystallization.)

	Grains.
Potassium sulphate	2·606
Sodium sulphate	89·859
" chloride	296·477
" bromide	trace.
" iodide	strong trace.
Calcium sulphate	28·943
" bicarbonate	17·394
Magnesium sulphate	65·281
Ferrous bicarbonate	0·282
Silica	1·127
Organic matter	trace.
	501·969
Carbonic anhydride, free	5·774
	507·743

Lithia, baryta, strontia and boric anhydride were sought for, and found to be absent.

4.—Water from a boring in Front street, Courtright, Lambton co., Ont. Depth of boring, one hundred and thirty feet. Rate of flow, one hundred and sixty-five gallons per hour.

The sample of water sent for examination was perfectly bright and clear; colourless; odourless; and devoid of any marked taste. It reacted neutral: after evaporation to a small

volume, however, decidedly alkaline. Its specific gravity, at 15·5° C., was found to be 1001·29. Boiling produced a slight precipitate, consisting of calcium carbonate with a little magnesium carbonate.

An analysis, by Mr. Wait, showed one thousand parts, by weight, of this water, at 15·5°C., to contain:

Potassa	0·003
Soda	0·457
Lime	0·029
Magnesia	0·012
Sulphuric anhydride	trace.
Carbonic anhydride	0·204
Chlorine	0·420
Iodine	trace.
Silica	0·011
Organic matter	trace.
	1·136
Less oxygen, equivalent to chlorine	0·095
	1·041

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination.

(The carbonates being calculated as monocarbonates, and all the salts estimated as anhydrous.)

Potassium sulphate	trace.
Potassium chloride	0·005
Sodium chloride	0·689
" iodide	trace.
" carbonate	0·157
Calcium carbonate	0·052
Magnesium carbonate	0·025
Silica	0·011
Organic matter	trace.
	0·939
Carbonic anhydride, half-combined	0·101
" " free	0·002
	1·042

Total dissolved solid matter, by direct experiment, dried at 180° C., =0·888.

An imperial gallon of the water, at 15·5° C., would contain:

(The carbonates being calculated as anhydrous bicarbonates, and the salts without their water of crystallization.)

	Grains.
Potassium sulphate	trace.
Potassium chloride	0·350
Sodium chloride	48·292
" iodide	trace.
" bicarbonate	15·560
Calcium bicarbonate	5·257
Magnesium bicarbonate	2·664
Silica	0·770
Organic matter	trace.
	72·893
Carbonic anhydride, free	0·140
	73·033

Bromine was sought for, and not detected.

5.—Water from a well at Ingram, on the main line of the Canadian Pacific railway, four miles and a half west of Grenfell station, Sask. The well in question is ten feet in diameter and ten feet deep.

The sample of water procured for examination was perfectly clear, bright and colourless. It was odourless and devoid of any marked taste Reacted neutral, both before and after concentration. Boiling produced a small precipitate, consisting of calcium carbonate with some magnesium carbonate.

One thousand parts, by weight, of this water, at 15·5°C., were found by Mr. Wait to contain :

Potassa	0·006
Soda	0·175
Lime	0·261
Magnesia	0·234
Sulphuric anhydride	0·707
Carbonic anhydride	0·297
Chlorine	0·038
Silica	0·020
Organic matter	trace.
	1·738
Less oxygen, equivalent to chlorine	0·009
	1·729

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination :

(The carbonate being calculated as monocarbonate, and all the salts estimated as anhydrous.)

Potassium sulphate	0·011
Sodium sulphate	0·323
Sodium chloride	0·063
Calcium sulphate	0·634
Magnesium sulphate	0·220
Magnesium carbonate	0·338
Silica	0·020
Organic matter	trace.
	1·609
Carbonic anhydride, in excess of that required to form monocarbonate	0·120
	1·729

Total dissolved solid matter, by direct experiment, dried at 180° C., =1·548

The amount of carbonic anhydride found, in excess of that required to form normal carbonate, is, approximately, one-third less than that required for the conversion of this into bicarbonate. For this reason, the neutral carbonate is, in the following statement, represented as being present in that condition.

An imperial gallon of the water at 15.5°C., would contain : (The carbonate being calculated as monocarbonate, and all the salts estimated as anhydrous.)

	Grains.
Potassium sulphate	0·772
Sodium sulphate	22·655
Sodium chloride	4·419
Calcium sulphate	44·468
Magnesium sulphate	15·341
Magnesium carbonate	23·707
Silica	14·03
Organic	trace.
	112·855
Carbonic anhydride, in excess of that required to form monocarbonate	8·417
	121·272

6.—Water from a well at Whitewood, on the main line of the Canadian Pacific railway, thirty-one miles east of Grenfell station, Sask.

The sample of water procured for examination was perfectly clear, bright and colourless. It was odourless, and devoid of any marked taste. Reacted neutral, both before and after concentration. Boiling produced a small precipitate, consisting of calcium carbonate with some magnesium carbonate.

Agreeably with the results of an analysis conducted by Mr. Wait, one thousand parts, by weight, of this water, at 15·5° C., contained:

Potassa	0·013
Soda	0·280
Lime	0·464
Magnesia	0·273
Sulphuric anhydride	1·035
Carbonic anhydride	0·553
Chlorine	0·048
Silica	0·027
Organic matter	trace.
	2·693
Less oxygen, equivalent to chlorine	0·011
	2·682

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonate being calculated as monocarbonate, and all the salts estimated as anhydrous).

Potassium sulphate	0·020
Sodium sulphate	0·545
Sodium chloride	0·079
Calcium sulphate	1·127
Magnesium sulphate	0·087
Magnesium carbonate	0·512
Silica	0·027
Organic matter	trace.
	2·397
Carbonic anhydride, half-combined	0·268
" free	0·017
	2·682

Total dissolved solid matter, by direct experiment, dried at 180° C., = 2·316.

An imperial gallon of the water, at 15·5° C., would contain: (The carbonate being calculated as anhydrous bicarbonate, and the salts without their water of crystallization.)

	Grains.
Potassium sulphate	1·403
Sodium sulphate	38·245
Sodium chloride	5·544
Calcium sulphate	79·087
Magnesium sulphate	6·105
Magnesium bicarbonate	54·737
Silica	1·895
Organic matter	trace.
	187·016
Carbonic anhydride, free	1·193
	188·209

7.—Water from a boring (for coal) at Rear brook, East river, opposite Trenton, Pictou co., N.S. It was struck at a depth of 2,254 feet from the surface, and rises from the base of the New Glasgow conglomerate, Permian.

The sample of water sent for examination contained a small quantity of reddish-brown, flocculent matter in suspension which, on removal by filtration, was found to consist of hydrated peroxide of iron with a very little organic matter. The filtered water was bright, colourless, and odourless. It had a strongly saline, slightly acrid taste, succeeded by a bitter one. Reacted, faintly acid. The total dissolved saline matter, dried at 180° C., amounted to 127.972 parts per 1000—equivalent to 8958.04 grains per imperial gallon.

A qualitative analysis, by Mr. Wait, indicated the presence of :

Soda	somewhat large quantity.
Lime	large quantity.
Magnesia	rather small quantity.
Ferrous oxide	very small quantity.
Sulphuric anhydride	rather small quantity.
Chlorine	large quantity.
Silica	trace.

Boiling produced a very slight precipitate, consisting of ferric hydrate.

8.—Water from a well near the Post Office at Granville Centre, Annapolis co., N.S. The well has a depth of six feet, the upper five feet passing through a stiff red clay and the lower one foot through gravel, from which the water rises.

The water contained a very small quantity of pale brown, flocculent matter in suspension. This, on removal by filtration, was found to consist of organic matter with a trifling quantity of hydrated peroxide of iron. The filtered water, when viewed in a column two feet in length, was found to have a pale brownish-yellow colour. It was odourless; devoid of any marked taste; and reacted neutral, both before and after concentration. The total dissolved saline matter, dried at 180° C., amounted to 0·142 parts per 1000, which would be equivalent to 9·94 grains per imperial gallon.

A qualitative analysis, conducted by Mr. Wait, showed it to contain:

Potassa	trace.
Soda	small quantity.
Lime	very small quantity.
Magnesia	" " "
Sulphuric anhydride	" " "
Carbonic anhydride	" " "
Chlorine	" "
Silica	trace.
Organic matter	"

Boiling produced a slight precipitate, consisting of calcium carbonate.

9.—Water from what is known as the "How" spring, lot 15, con. 3, Fitzroy tp., Carleton co., Ont.

The sample sent was, at the time of its receipt, somewhat turbid, and after standing for a short time deposited a very small quantity of what proved to be a slightly ferruginous argillaceous matter. After filtration, this water was found to be bright and, apparently, colourless, but when viewed in a column two feet in length, it was seen to have a faint yellowish tinge. It was odourless; possessed a mildly saline taste; and reacted neutral, both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1008·0. The total dissolved saline matter, dried at 180° C., amounted to 9·524 parts in 1000 parts, by weight, of the filtered water, which would be equivalent to 666·68 grains per imperial gallon.

Agreeably with the results of a qualitative analysis, conducted by Mr. Wait, it contained:

Potassa	trace.
Soda	somewhat large quantity
Lime	small quantity.
Magnesia	" "
Ferrous oxide	trace.
Sulphuric anhydride	small quantity.
Carbonic anhydride	rather small quantity.
Chlorine	somewhat large quantity.
Silica	trace.
Organic matter	trace.

Boiling produced a somewhat copious precipitate, consisting of calcium carbonate, with some magnesium carbonate, and a trifling quantity of ferric hydrate.

10.—Water from the coal mine at Frank, Alta.

The sample received for examination contained a small quantity of dark brownish-black sedimentary matter which, on removal by filtration, was found to consist of flocculent organic matter with some very finely divided coaly matter, a very small quantity of basic ferric sulphate, and a little siliceous matter. The filtered water was bright and had, when seen in a clear glass vessel of moderate capacity, a brownish-yellow, but when viewed through a column two feet in length, a deep red, colour. It reacted strongly acid; and possessed a styptic taste. ts specific gravity, at 15·5° C., was found to be 1017·5.

A qualitative analysis, by Mr. Wait, showed it to contain:

Lime	small quantity.
Magnesia	very small quantity.
Ferrous oxide	" " "
Ferric oxide	rather large quantity.
Sulphuric anhydride	" " "
Chlorine	trace.

In addition to the foregoing, this water also contained a considerable quantity of free sulphuric acid.

On heating, it became turbid, and at the boiling temperature deposited a dense brownish-yellow precipitate consisting, essentially, of basic ferric sulphate.

Its chief constituents consisted, evidently, of ferric sulphate with a little ferrous sulphate and some free sulphuric acid.

11.—Water from a spring near Baker or Cannington lake, on the east side of Moose mountain, tp. 9, range II, west of the second initial meridian, Sask.

The sample sent for examination contained a very small quantity of light brown flocculent matter in suspension. This, on removal by filtration, was found to consist, essentially, of organic matter with a very little ferric hydrate. The filtered water, which was perfectly clear and bright, had a brownish-yellow colour. It was odourless, devoid of any marked taste, and reacted neutral—both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1001·0, and the total dissolved saline matter, dried at 180° C., amounted to 0·566 parts per 1000—equivalent to 39·66 grains per imperial gallon.

A qualitative analysis, conducted by Mr. Wait, indicated the presence of :

Soda	very small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Ferrous oxide	trace.
Sulphuric anhydride	very small quantity.
Carbonic anhydride	small quantity.
Chlorine	trace.
Silica	"
Organic matter	"

Boiling produced a small precipitate, consisting of calcium carbonate with a little magnesium carbonate and a trace of ferric hydrate.

12.—Water from a coal mine, worked by the Souris Coal Mining Company, on section 4, tp. 2, range VI, west of the second initial meridian, Sask.

Two samples of the water from this mine were sent for examination. Of these, the one—A., represented the water which percolates through the strata into the mine; and the other—B., represented the water discharged by the pumps from the mine.

A. This water was clear, bright, and of a pale brownish-yellow colour. It was inodorous ; devoid of any marked taste ;

and reacted neutral, but after evaporation to a small volume, decidedly alkaline. Its specific gravity, at 15·5° C., was found to be 1001·5. It contained 0·60 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water, which would be equivalent to 42·06 grains per imperial gallon.

A qualitative analysis, by Mr. Wait, showed it to contain :

Potassa	trace.
Soda	small quantity.
Lime	" "
Magnesia	very small quantity.
Sulphuric anhydride	small quantity.
Carbonic anhydride	rather small quantity.
Chlorine	none.
Silica	trace.
Organic matter	"

Boiling produced a small precipitate, consisting of calcium carbonate with a very little magnesium carbonate.

B. This was very turbid, owing to the presence of suspended argillaceous matter. When freed from the latter by filtration the water was seen to have a brownish-yellow colour. It had a faint argillaceous odour; no marked taste; and reacted neutral,—after concentration, however, strongly alkaline. Its specific gravity, at 15·5° C., was found to be 1002·5. The total dissolved saline matter, dried at 180° C., amounted to 1·6 parts in 1000 parts, by weight, of the filtered water,—equivalent to 112·28 grains per imperial gallon.

A qualitative analysis, conducted by Mr. Wait, gave as follows :

Potassa	trace.
Soda	somewhat large quantity.
Lime	small quantity.
Magnesia	very small quantity.
Sulphuric anhydride	small quantity.
Carbonic anhydride	somewhat large quantity.
Chlorine	very small quantity.
Silica	trace.
Organic matter	strong traces.

Boiling produced a small precipitate, consisting of calcium carbonate with traces of magnesium carbonate.

Determinations of the oxygen consuming power of these waters showed the absorption,—in the case of water A., to be but slight; in that of water B., quite considerable.

13.—Water from a hot spring near Vancouver, B.C.

The sample received for examination was clear, colourless, and bright; inodorous, and devoid of any marked taste. It reacted neutral, both before and after concentration. Its specific gravity, at 15·5° C., was found to be 1001·5. The total dissolved saline matter, dried at 180° C., amounted to 1·155 parts per 1000,—equivalent to 80·92 grains per imperial gallon.

A qualitative analysis, by Mr. Wait, indicated the presence of:

Soda	small quantity.
Lime	" "
Magnesia	trace.
Sulphuric anhydride	small quantity.
Chlorine	" "
Silica	trace.
Organic matter	"

Boiling did not produce any perceptible precipitate.

BRICK AND POTTERY-CLAYS.

1.—Clay from what is said to be an extensive deposit occurring on section 28, tp. 12, range XXIV, west of the second initial meridian, Sask.

This clay has, in the air-dried condition, a bluish-greyish-white colour. It contains but a small quantity of siliceous grit; is highly plastic; burns white, or nearly so; and is very difficult to fuse at an elevated temperature.

Its analysis afforded Mr. Wait the following results:—

Silica	62·30
Alumina	22·24
Ferrous oxide	2·07
Lime	0·60
Magnesia	0·18
Alkalies, by difference	3·21
Water (ignition)	9·40
	100·00

This clay affords a very strong brick, and it is therefore particularly well adapted for the manufacture of building brick. It might also be advantageously employed in the manufacture of stove linings, and even fire-brick in which an exceptionally high degree of refractoriness was not called for, and could likewise be used in the manufacture of pottery, including the finer varieties of stoneware.

A precisely similar clay has been met with in the vicinity of Pasqua about seven miles east of Moosejaw, Sask. The deposit from which the latter was taken may possibly be an extension of that above referred to, which is situated about thirty miles southeast of Moosejaw.

2.—Clay from a deposit on the farm of Angus McLean, French Vale, Cape Breton co. N.S.

A slightly calcareous, slightly ferruginous, somewhat strongly plastic clay, through which is disseminated a rather large proportion of grit, composed, for the most part of quartz and feldspar, with some hornblende, chlorite, and mica, and a few particles of pyrite. It is somewhat readily fusible at an elevated temperature. When burnt it assumes a reddish-brown colour. It affords a strong brick.

3.—Clay from a deposit occurring on, or near, the bay shore and about a mile from the town of Baddeck, Victoria co., N.S.

A dull reddish-brown, non-calcareous, slightly ferruginous, somewhat strongly plastic clay, containing a small quantity of gritty matter. When burnt it assumes a bright reddish-brown colour. It is readily fusible at a somewhat elevated temperature. This clay might advantageously be employed for the manufacture of building bricks, drain-tiles, and all kinds of common earthenware.

4.—Clay from Garlic mountain, about seven miles from the town of Baddeck, Victoria co., N.S.

A greyish-white, non-calcareous, but very slightly ferruginous strongly plastic clay, containing a small quantity of gritty matter. It is somewhat readily fusible at an elevated temperature. When burnt it assumes a light reddish-white colour.

It affords a strong brick, and would, apart from its employment for the manufacture of ordinary building brick, be well suited for the manufacture of drain-tiles and coarse earthenware.

5.—Clay from Arichat, Richmond co., N.S.

A light reddish-grey, non-calcareous, slightly ferruginous rather feebly plastic clay, through which is distributed a large proportion of fine siliceous grit. It is somewhat difficult to fuse and affords a fairly strong brick of a light reddish-brown colour.

6.—Clay from a deposit on Dutch Valley road, Sussex, Kings co, N.B.

A calcareous—the calcium carbonate amounting to, approximately, 10·7 per cent,—somewhat ferruginous, rather feebly plastic clay, through which is disseminated a little gritty matter. It is readily fusible at an elevated temperature. When burnt it assumes a light reddish-brown colour. It affords a very strong brick.

7.—Clay from a boring two miles east of The Brook village, Clarence tp., Russell co., Ont.

A light brownish-grey, slightly calcareous, slightly ferruginous, rather strongly plastic clay, through which is distributed a small quantity of gritty matter, and a few scales of yellow mica. It is readily fusible at an elevated temperature. When burnt it assumes a light reddish-brown colour. It affords a strong brick.

8.—Clay from a deposit extending over lots 10 and 11, con. 3, Sarawak tp., Grey co., Ont.

A bluish-grey somewhat highly calcareous, slightly ferruginous, readily fusible, highly plastic clay, containing a very small quantity of fine siliceous grit. When burnt it assumes a light reddish-brown colour. It affords a strong brick, and is well suited for the manufacture not only of ordinary building brick, but also drain-tiles and all kinds of coarse earthenware.

9.—Clay from Red river, where it occurs on blocks 9, 13, 14 and 15, of river lot 13, Kildonan, about three miles northeast of Winnipeg.

A light brownish grey, somewhat highly calcareous, non-magnesian, rather strongly ferruginous, highly plastic clay, through which is distributed a very small quantity of fine siliceous grit. It fuses readily at an elevated temperature. When burnt it assumes a bright reddish-brown colour. It affords a strong brick, and might advantageously be employed for the manufacture of ordinary building brick, as well as drain-tiles and other kinds of common earthenware.

10.—Clay from a deposit on, or near, Prairie creek—a tributary of Clearwater river, near Rocky Mountain House, Alta.

A bluish-grey, calcareo-magnesian, somewhat ferruginous, rather strongly plastic clay through which is disseminated a small quantity of fine siliceous grit. It is easily fusible at a somewhat elevated temperature. Determinations of certain of the constituents of this clay showed it to contain, approximately, calcium carbonate 32·59, magnesium carbonate 12·6, ferrous oxide 1·93, and ferric oxide 2·00 per cent. The siliceous grit amounted to, approximately, 3 per cent. It affords a strong brick, of a pleasing light reddish-brown colour.

11.—Clay from a bed, five to seven feet in thickness, occurring, at a depth of five feet from the surface, on the north-half of section 11, tp. 29, range XXIII, west of the fourth initial meridian, Alta.

A dark grey, rather strongly calcareous, somewhat highly magnesian, rather strongly ferruginous, readily fusible, plastic clay, containing a very little fine siliceous grit diffused through its substance. It affords a strong brick, of a reddish-brown colour, and is well adapted for the manufacture both of common building brick, and coarse earthenware in general.

12.—Clay from a bed some ten feet in thickness, immediately underlying that from which the preceding specimen was taken.

A light grey, rather strongly calcareous, somewhat highly magnesian, slightly ferruginous, rather plastic clay, through which is distributed a small quantity of fine siliceous grit. When burnt it assumes a light reddish-brown colour. Is easily fusible at a somewhat elevated temperature. Like the preceding clay, it affords a strong brick. It might be used for the manufacture of ordinary building brick, drain-tiles, and similar ware.

13.—Clay from a deposit occurring on section 1 or 12 or both, of tp. 24, range I, west of the fifth initial meridian, Alta.

A brownish-grey, somewhat strongly calcareous, slightly magnesian, and slightly ferruginous, rather readily fusible, strongly plastic clay, holding numerous rounded pebbles of quartz, sandstone, and limestone, and also containing a very large quantity of fine siliceous grit. After separation of the pebbles in question, the clay itself was found to contain, approximately, calcium carbonate 13·46, magnesian carbonate 3·38, and intermixed fine siliceous sand 42·00 per cent. It afforded a strong brick of a reddish-brown colour.

14.—Clay occurring on the homestead of Mr. A. M. Kay, section 34, tp. 32, range I, west of the fifth initial meridian, Alta., about one mile and a half east of the town of Olds, Calgary div., Alta.

A greenish-grey, somewhat highly calcareous, slightly magnesian, slightly ferruginous, rather feebly plastic clay, which burns reddish-white, is somewhat difficultly fusible at an elevated temperature, and affords a strong brick. It might be employed for the manufacture of ordinary building brick, drain tiles, and similar ware.

15.—Clay from a deposit on the west-half of section 19, tp. 7, range III, west of the fifth initial meridian, Alta.

A light greenish-grey, slightly calcareous, very slightly magnesian, slightly ferruginous, feebly plastic, readily fusible clay, containing a small quantity—approximately 13 per cent, of fine grit composed, essentially; of quartz and feldspar. When burnt it assumes a dull reddish-brown colour. It affords but a weak brick.

16.—Clay from the same locality as the preceding specimen.

A bluish-grey, somewhat highly calcareous, slightly magnesian, and slightly ferruginous, feebly plastic, readily fusible clay, containing a somewhat large quantity—approximately 27 per cent, of fine grit composed, chiefly, of quartz and feldspar. It affords a fairly strong brick of a reddish-brown colour.

17.—Clay from the same locality as the two preceding specimens.

A light greenish-grey, slightly calcareous, non-magnesian, slightly ferruginous, readily fusible, rather strongly plastic

clay, containing only a small quantity—approximately 5 per cent, of fine grit composed, mainly, of quartz and feldspar. It yields a strong brick of a bright reddish-brown colour, and is quite suitable for the manufacture of common building brick and coarse earthenware.

18.—Clay from the same locality as the three preceding specimens. A light greenish-grey to light grey, slightly calcareous, very slightly magnesian, slightly ferruginous, feebly plastic, easily fusible clay, containing a somewhat large quantity—approximately 30 per cent, of fine siliceous grit composed, for the most part, of quartz and feldspar. It affords a strong brick of a reddish-brown colour.

19.—Claystone, from mountain three miles east of Enderby, Yale district, B.C.

It has a dark grey colour; is non-calcareous; slightly ferruginous; has a small quantity of fine siliceous grit and a few minute scales of mica, diffused through its substance; disintegrates when immersed in water; in the moist condition is feebly plastic; when burnt assumes a reddish-brown colour; and is easily fusible at a somewhat elevated temperature. It affords a strong brick.

A similar material—claystone, has been met with about four miles north of Clinton, Lillooet district, B.C., as mentioned in the Annual Report, vol. xii, p. 61 R., for 1899.

MISCELLANEOUS EXAMINATIONS.

1.—Arenaceous clay. From a deposit occurring some ten or twelve miles west of Desbarats, Algoma dist., Ont.

A slightly calcareous, very slightly magnesian, and slightly ferruginous, readily fusible, somewhat strongly plastic clay, through which is disseminated a very large quantity—approximately 63 per cent, of exceedingly fine-grained siliceous sand— When burnt it assumes a light reddish-brown colour. Notwithstanding the large proportion of siliceous sand, it affords quite a strong brick.

2.—Bog manganese. From a deposit on the farm of Mr. F. McAulay of Cardigan, St. George parish, P.E.I.

A partial analysis of this, by Mr. Wait, showed it to contain —manganese dioxide 35·44, ferric oxide 34·91, insoluble siliceous matter 3·60, water, hygroscopic and combined, 18·63, per cent.

3.—Carbonaceous shale. From the shore of Tagish lake, about forty miles southeast of Dugdale station on the line of the White Pass and Yukon railway, Ykn.

A greyish-black, lustrous, slickensided, carbonaceous shale. It contained 11·234 per cent of fixed carbon.

4.—Ferruginous shale. From Oak mountain, Carleton co., N.B.

A specimen of a reddish-brown, argillaceous shale, traversed by an occasional thin seam of quartz, from this locality, was found to contain—16·50 per cent of ferric oxide, equivalent to 11·55 per cent of metallic iron.

5.—Graphitic shale. From an occurrence of this material on the farms of Mr. Donald McInnis and Mr. McSween, on Big brook, near West Bay Road station, Inverness, co., N.S., about half a mile from the railway.

Three samples of the material from this locality, where it is met with in the Lower Carboniferous, have been examined by Mr. Wait and found to contain, respectively,—26·59, 31·57, and 35·53, per cent of graphitic carbon.

6.—Molybdenite. From one of the veins constituting what is known as the Tamarac group on Gnawed mountain, Yale dist., B.C.

The material received for examination consisted of a white subtranslucent quartz traversed by thin veinings of molybdenite and holding a very small quantity of chalcopyrite. A fair average sample of the particular specimen sent was found by Mr. Wait to contain, approximately, 7 per cent of molybdenite.

7.—Silt. A very fine-grained, compacted, yet readily friable, somewhat argillaceous, siliceous silt, has been found, forming a bed immediately overlying a bed of arenaceous clay, at a point some ten or twelve miles west of Desbarats, Algoma dist., Ont.

A partial analysis, by Mr. Wait, of a sample of this material, dried at 100° C., showed it to be composed of, approximately,—minute grains of siliceous sand 75·0; calcium carbonate 15·2; magnesium carbonate 4·0; ferric oxide, trace; clay 5·8=100·0. When moistened with water it forms a somewhat plastic mass, which, when dried and burnt assumes a reddish-white colour, is tender, and readily fusible at an elevated temperature.

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858. Manganese.
859. Salt.
860. Zinc.
869. Mica.
872. Molybdenum and Tungsten.
877. Graphite.
880. Peat.
881. Phosphates.
882. Copper.
913. Mineral Pigments.

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961. Reprint of No. 873.
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GEOLOGICAL SURVEY OF CANADA
A. P. LOW, Deputy Head and Director.

MOOSE MOUNTAIN DISTRICT

OF

SOUTHERN ALBERTA

BY

D. D. CAIRNES.

OTTAWA:
GOVERNMENT PRINTING BUREAU
1907

No. 968.

To A. P. Low, Esq.,
Deputy Head and Director,
Geological Survey of Canada.

SIR.—I beg to submit the following report on the Moose Mountain distuict of southern Alberta. A topographical and an economic map accompany this report. I wish particularly to thank Mr. D. B. Dowling of this Department for his very valuable assistance in writing and compiling this report and these maps.

I have the honour to be, Sir,
Your obedient servant,

D. D. CAIRNES.

March 12th, 1907.

TABLE OF CONTENTS.

REPORT

TO

ACCOMPANY MAP OF THE MOOSE MOUNTAIN AREA OF THE DISTURBED BELT

SOUTHERN ALBERTA

INTRODUCTION.

This report and the map which accompanies it cover that area south of and adjoining the Bow river from the main Rocky Mountain escarpment on the west, to include part of range III, west of the 5th initial meridian on the east, and extending south to tp. 18, *i. e.*, to a short distance south of the south branch of Sheep river.

Coal had been found in several places within this district and natural gas had been found to the north, south, and east of this area in the same formations as those within it. So it was decided to study these coal and gas horizons in sufficient detail to place their outcrops upon the map and to be able to give geological sections at any desirable points. In this way the work of those looking for gas and coal is very much simplified and considerable definite information is afforded.

It has previously been supposed that the Kootanie formation, within the mountains, did not extend east of the main Rocky Mountain escarpment; but this season it has been found here, and as this is the formation which carries the high grade coals of the Crowsnest pass and of the Cascade trough, at Banff and Canmore, the finding of it in this area will prove of interest to many, especially as the measures, although much thinner than to the west, still carry several workable seams of good quality in nearly every place found, and extend the entire length of the map.

The coal measures in the Judith River and Edmonton are not nearly so easily followed as those of the Kootanie formation, which is somewhat narrow and is capped by a very prominent conglomerate, forming, usually, the summits of the points and ridges of the district in which it outcrops, and in the 300 to 400 feet below which the coal seams are always to be found. As this conglomerate can be traced, quite easily, from one end of the district to the other, prospecting for

this coal is comparatively easy. On the map to accompany this report the Kootanie is shown by a plain geological colour, but a section made at any point across it will show several coal seams. The coal outcrops of the Edmonton and Judith River are indicated by a heavy red line; many more may be found, however, than those shown.

The coals of the Judith River are of a slightly higher grade than those of the Edmonton, and the quality, in either formation, goes up as the mountains are approached. This is caused by the pressure due to the folding and twisting of the rocks, which will even, at times, cause a considerable variation in the same seam in a few feet. The Kootanie coals are found as anthracitic coals, semi-anthracites, or bituminous coals, according to the amount of local pressure. At one place on the south branch of Sheep river one of these seams, in a tight fold, has been altered to an impure graphite. The Edmonton coals are all lignites or lignitic coals. A few samples collected give evidence by analyses of being the latter.

COALS.

Kootanie Coals.

The Kootanie coal measures outcrop all around the Moose Mountain ridge; from Gleasons Meadow, along the east side of the ridge through Gleason and Lower Camp; along the northwestern and eastern slopes of Coxcomb mountain, near its summit, and thence to the north end of Forgetmenot ridge; on Jumpingpound creek, north of Coxcomb mountain; on the south branch of Sheep river north of Hoffmann mountain; and in a few other places, as shown on the map to accompany this report.

At the head of Bragg creek, near the old Thorne mine, which is situated on the N.E. ¼ of sec. 8, tp. 23, R. VI., west of the 5th meridian, a section was measured from the conglomerate at the bottom of the Dakota to the Palæozoic. The Thorne mine was worked for the disseminated iron pyrites in the Fernie shales. The iron occurs here in blossoms quite thickly distributed, but of no present economic value whatever. These black shales are quite calcareous in places, and on one of the weathered dumps of the old mine workings were found a great number of specimens of guards of Belemnites, which were very helpful in determining the horizon of this formation. This mine has long since been abandoned, but the remains of an old road still exist, corduroyed in places, up to the old cabins just below the mine workings. The coal measures are very plainly seen on the north side of the creek opposite the mine, but, although deeply covered by wash the seams

appear less disturbed just above it, where the following section was measured:—

	Feet.	Inches.
Dark brown shale	1	0
Coal	1	6
Brown shale	42	0
Sandstone	7	3
Brown shale	3	6
Dark coarse sandstone	22	0
Sandstone and shale	15	6
Coal	1	6
Gray sandy shales	2	3
Coal	3	7
Dark gray shales	8	3
Coal	1	10
Dark brown sandstones and shales	21	0
Coal	2	3
Dark sandstones and shales	73	0
Coal	8	2
Brown coarse sandstones	24	0
Coal	6	10
Dark coarse shales	4	3
Dark blue shales	9	0
Shales and sandstones	23	0
Brown prominent sandstone bed	63	0
Total thickness of Kootanie	344	8
Total thickness of coal	25	8
Dark Fernie shales	195	0

An average outcrop sample of the eighteen-inch seam in the above section, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1.86%	19.23%	76.07%	2.84%

An average outcrop sample of the seven foot, six-inch seam, north of the creek, opposite the mine, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1.17%	13.54%	69.77%	15.52%

An average outcrop sample of the six foot, ten-inch seam in the above section, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
2.74%	18.62%	75.52%	3.12%

These analyses were made by Dr. Hoffmann, of this department. Concerning the last sample, he also says:—

"Structure, somewhat coarse lamellar, made up of irregularly alternating layers of grayish-black, somewhat bright and dense, jet-black coal of brilliant lustre, with an occasional interposed film of mineral charcoal, contorted, shows slickensides in an eminent degree,—compact; firm; fracture, irregular; powder, brownish-black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash."

As the above measures cross the creek bottom the coal could be conveniently mined to advantage by tunnels run in on seams at convenient levels above the creek.

Elbow River.

Near the top of Forgetmenot ridge, half a mile north of the Elbow river, the following seams were measured, but others may be there as the section was rapidly made. Considerable work would be here required to get a perfectly accurate and complete section:

	Feet.	Inches.
1 coal seam	5	4
1 "	2	6
1 "	4	0
2 coal seams, each	2	0
1 coal seam	1	2
1 "	0	11
1 "	0	10
1 "	0	9
2 coal seams, each	0	8
1 coal seam	0	7
1 "	0	6
Total	21	11

An average outcrop sample of very badly weathered coal was taken from the five foot, four inch seam in the above section, and gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
6.68%	20.68%	64.71%	7.93%

The measures outcrop equally well on both the north and south sides of the Elbow, and the outcrop could easily be traced to the river level where it could be definitely fixed with a small amount of work, thus affording favourable points for mining by driving in on the coal at convenient levels above the river.

South Branch of Sheep River.

The Kootanie formation outcropping along the eastern side of Lower Camp on the south branch of Sheep river is somewhat narrow, and the coal is of less importance than at many other localities visited this season. This is due, to some extent, to the extensive fault running north and south, just east of the measures here, which, in all probability, cuts off part of the originally exposed formation. A slope with a very low angle of dip has been run on a three foot seam in these measures for a considerable distance, the entrance to which is just above the wagon road running up this river. This is the best seam noticed here. An average outcrop sample analysed by Dr. Hoffmann, yielded:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
0.69%	19.98%	73.12%	6.21%

The sample was taken from the surface as the slope was filled with water.

These same measures also outcrop on the north side of Hoffmann mountain, farther up the river, and in the river banks below it. At

one place here the coal was so much squeezed and the seams so irregular that they vary from a few inches to several feet, in almost the same distance. The coal of one seam has been so altered that in a tight part of a fold it has been altered to an impure graphite.

Farther up the river, about a quarter of a mile, where the coal again appears, one seam about three feet six inches wide was noticed, which, for some distance at least, is quite regular. An average outcrop sample was analysed by Dr. Hoffmann, giving:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
0.53%	14.99%	64.55%	19.93%

"It yields by fast coking, a compact, firm, coherent coke."

Places could likely be found here where this coal could be profitably worked if there was a demand for it, especially as there is a good wagon road up this far.

Coxcomb Mountain.

Near the top of Coxcomb mountain the Kootanie coal measures outcrop for some distance, but a complete section was not seen. There appear to be, however, at least four or five seams, and some may be of workable width, but those seen were only thirty-six, twenty-three and nineteen inches, respectively.

An average outcrop sample of the thirty-six inch seam, analysed by Dr. Hoffmann, shows it to be an anthracitic coal and gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1.64%	14.26%	82.01%	2.09%

But since the measures outcrop in so many places, at all elevations from the level of Jumpingpound creek, below, to the mountain summits on both sides of it, and along it for about four miles and south of Jumpingpound mountain, as shown on the map, there is a likely chance of finding quite accessible points at which the seams are of sufficient width and regular enough to be economically worked; since the quality of the coal itself is good. Where the measures outcrop along Jumpingpound creek to the north of Coxcomb mountain no seams were noticed over a few inches in width. Several feet of carbonaceous shale outcrop, however, in one place.

Where the Kootanie formation outcrops, on a branch of Lusk creek running into it from the east, only the upper part of the formation is exposed, and as the dips here are about flat whatever coal exists is below the surface.

There is no reason to suppose that the places where the coal was measured are better than others. They were simply convenient places where the seams could be measured without much digging being necessary. There was no point along the Kootanie outcrop where any considerable portion of the formation was exposed that coal was not seen if search was made.

P. Burns' Coal Basin.

Just inside the first limestone range, at the head of the south branch of Sheep river, is a Cretaceous trough containing a considerable amount of coal. This was not followed far south of Sheep river, although it appears to run some distance in this direction toward Highwood river. The Kootanie rocks which carry the coal here are very similar to those outside the mountains, but are very much thicker. The P. Burns' coal property includes the southern part of that portion of this basin shown on this map. Here the Cretaceous exists in the form of a very rugged line of hills, almost as much so, in places, as the Palæozoic mountains on both sides.

Lying immediately on the limestones are 200 to 300 feet of fine-grained quartzites varying in colour from almost pure white to a light gray. Next above these are some very dark, almost black, shales. Above these again are the Kootanie rocks, which extend from near the river level to the summits of the mountains. These hills extend along the valley in a northwesterly direction for about four miles from the main workings, when they rapidly begin to disappear, and from there to the northern end of the trough only the lower rocks still exist, the upper coal-bearing strata having been eroded away.

A section was made up one of the gulches where work has been done on the coal, but as it was hurriedly made there may be more seams than those noticed, as parts of the section were covered by drift. But all the seams that were exposed, or have been opened up at all, are included in the following, except three narrow ones from one foot to three feet in thickness, which were seen a few hundred feet above the section measured and some considerable distance apart. This section, as all others in this report, is given from the top down:—

	Feet.	Inches.
Sandstone	..	..
Coal	0	10
Sandstones	39	—
Coal	1	4
Sandstones and shales	322	..
Coal	1	2
Brown sandstones and shales	106	..
Coal	2	..
Dark coarse sandstones and dark shales	45	..
Coal, very clean	1	8
Brown sandstones with very little shale	193	..
Coal, dirty seam	2	10
Dark coarse sandstone, with few feet of shale	310	..
Coal, good	2	..
Sandstones and shales	80	..
Coal, very good clean regular seam	10	4
Brown sandstones and shales	427	..
Coal, with two feet of shale, two feet from hanging wall	9	6
Brown sandstones and shales	76	6
Coal, good clean seam	8	8
Brown sandstones	..	..
Total of coal	38	4

EDMONTON AND JUDITH RIVER COALS AND LIGNITES.

Bow River.

A seam of good lignite outcrops on the Bow river opposite the mouth of Coal creek (S.E. ¼, sec. 13, tp. 26, R. V.), but as the mine workings are now all caved in a section could not be seen; it appears, however, to be quite regular and of sufficient width to work near the river, but becomes very irregular and broken, up the creek. The horizon is probably near the base of the Edmonton. The seam is well exposed on the north bank of the river, just at the mouth of Coal creek, and at several points within a mile from the river. At the last point seen farthest from the river (S.W. ¼, sec. 24, tp. 26, R. V.), the seam is only three feet wide with ten inches of clayey parting near the centre. Considerable work has also been done here, being locally known as the Cochrane property. The workings on the south side of the river are known as the "Vaughan coal," "Mitford coal," or "Merritt coal."

Mr. J. B. Tyrrell has published in the Annual Report of this Department in 1886, the following section of the "Vaughan coal" property, furnished Dr. G. M. Dawson, by Mr. Vaughan; also the coal analyses given below, furnished by Dr. Hoffmann, of this Department:—

	Feet.	Inches.
Coal	1	0
Black shale	2	9
Coal	1	6
Clay	0	4
Coal	2	6
Clay	0	2
Coal	2	7

From the north side of the Bow river:

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
4.93%	27.22%	52.54%	15.3%

From the south side of the Bow river:

4.41%	40.32%	48.27%	7.00%

A one foot seam outcrops on the north bank of the Bow midway between the Railway bridge at Mitford and the mouth of Coal creek, or Grand Valley creek, as it is locally called.

On Mr. McPherson's place are several narrow seams of good firm lignite from six to eight inches wide:

S.W. ¼, sec. 16, tp. 26, R. V.
S.W. ¼, sec. 15, tp. 26, R. V.

An eighteen inch seam of somewhat powdered lignite outcrops on the south bank of the Bow river opposite Radnor; also a seam, possibly the same one, of soft shaly coal is exposed on the east bank of Ghost river. (S.W. ¼, sec. 24, tp. 26, R. V.)

A good clean-appearing seam of coal, six feet six inches wide, which has been worked to some slight extent by the Indians, outcrops on the Stony reserve, about three and a half miles northeast of the eastern end of Chiniquy lake. The coal dips to the west at about 30°, and has sandstone walls, with a few inches of mining next the foot wall. There is very heavy wash and drift here on all sides, so that little of the formation is exposed, but from what little can be seen the indications are very favourable for the economic working of this coal.

Dr. Hoffmann, of this Department, gives the following description of a sample from this locality, received from Mr. W. Pearce:—

"It has a crumpled, laminated structure, shows slickensides; is moderately firm; colour, grayish-black to black; lustre, resinous to vitreous; fracture, irregular; powder, black with a faint brownish tinge; it communicates a faint brownish-yellow colour to a boiling solution of caustic potash."

An analysis by fast coking gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1.26%	41.30%	48.60%	8.84%

"This is a true coal and yields, by fast coking, 57.44 per cent of compact, firm coherent coke."

Another two and a half foot seam of very similar appearing coal was seen about half a mile southeast of the above. No work had been done here and it is quite possible that other seams may exist in this vicinity.

Jumpingpound Creek.

On F. H. Towers' place (N.W. ¼, sec. 19, tp. 25, R. IV.) are several seams of very good lignite. One is four feet, six inches thick; one is fourteen inches, and there are a number from six inches to one foot in thickness. The two best seams make a very good domestic fuel and have been used locally to quite an extent. Difficulty in getting men who understand mining to work this coal has interfered materially in its development.

An average outcrop sample of this coal gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
5.0%	52.1%	35.2%	7.7%

This is, in all probability, of the same horizon as that at Coal creek, farther north.

A coal horizon was also recognized on Jumpingpound creek about one and three-quarter miles east of the mouth of Sibbald creek, which may be the same as that northeast of Chiniquy lake on the Stony Indian reserve. Only two very narrow seams, two to three inches thick, were noticed here; but coal was mined at this point a few years ago, so that

the seams which were worked have either pinched out or are covered over by a considerable amount of clay and dirt which has recently slid over the river bank here.

Elbow River.

A seam of coal, two feet six inches wide, outcrops in the north bank of the Elbow river (sec. 19, tp. 23, R. IV.), but the formation is nearly all somewhat deeply covered here for a considerable distance and very little bed-rock is to be seen.

Another seam, approximately two feet six inches wide, outcrops on sec. 33, tp. 22, R. V., in the south bank of the Elbow river. This is, probably, at the same horizon as the seams on Bragg creek to the north.

Bragg Creek.

Two seams of coal outcrop in the south bank of Bragg creek, sec. 7, tp. 23, R. V. Considerable work was done here a number of years ago, but all the works are now completely caved in. The following section was measured in the bank of the creek, but as there is very little outcrop either above or below this for some distance there may exist more coal than was seen.

Shales.	Feet.	Inches.
Coal	2	6
Bituminous shales	2	6
Sandstone	6	0
Coal	1	6
Sandstone	..	..

An average outcrop sample, analysed by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
9.31%	35.59%	41.72%	13.38%

South Branch of Fish Creek.

On the northwest ¼, sec. 7, tp. 22, R. III., are several seams of lignite known as "Shaw's coal." One tunnel was run over 180 feet on a seam here averaging about two feet in thickness, but it is very irregular and pinched down to a few inches in several places. An analysis of an average outcrop sample of this, made by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
3.76%	33.91%	56.37%	5.96%

There are other narrower seams here,—one is eighteen inches, and several vary from two to six inches.

On the northeast ¼, sec. 4, tp. 22, R. III., is a seam of lignite having a varying thickness of from two inches to three or four feet. The general dip is about flat, but the formation is somewhat irregular and undulat-

ing. There is an old caved-in tunnel on the north bank of the creek, showing that coal was mined here at one time. On the south side of, and up the creek 200 to 300 feet, is a seam, probably the same one. This property is known as "Patterson's coal."

North Branch of Fish Creek.

On the south bank of this creek and 400 or 500 feet from it, S.W. ¼, sec. 21, tp. 22, R. III., are a number of old mine workings, all now caved in or full of water.

The following section was obtained in one place near an old shaft:—

	Feet.	Inches.
Coal	2	0
Shale	0	6
Coal	3½ to 4	..
Shale	4 to 5	..
Coal	1	6

The dips are here about perpendicular.

This is known as "Gansby's coal" and is the most valuable of these Fish Creek coal properties, which are all of the same horizon and should prove of considerable importance. These coals seem to be at the same horizon as those at Lineham P. O. on the south branch of Sheep river and at Mr. Towers' place on Jumpingpound creek.

South Branch of Sheep River.

On the S.E. ¼, sec. 30, tp. 19, R. IV., is a seam over seven feet in thickness of very good appearing coal. An average outcrop sample, analysed by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
2.50%	35.88%	56.64%	4.98%

There are also several narrower seams here of only a few inches in thickness.

On the S.W. ¼, sec. 29, tp. 19, R. IV., occur several seams of coal a few feet apart. Two were noticed from five to six feet in thickness, and five from two to four feet. There are also two old tunnels that are entirely caved in, preventing an examination of the seams they have opened up. Below this point and within a distance of about three miles, a number of seams from a few inches to three feet outcrop, and there are probably others which were not seen. These measures are somewhat irregular in places, but regular points may be found. On account of the steep, high banks, and the high hills to the south, good facilities are offered for prospecting and mining.

An average outcrop sample of the five foot seam above, analysed by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
2.16%	34.65%	56.42%	6.77%

The Sheep Creek coals here are in the Judith River formation and the analyses show them to be true coals and of a better and higher grade than the Edmonton lignites and some of the Judith River coals. There is also a good wagon road along the river here, making them quite accessible, and they should prove of considerable value in the near future.

Mr. D. B. Dowling has written a paper entitled "Notes on the Utilization of the Poorer Grades of Coal and Slack," which is published in Vol. IX of the Journal of the Canadian Mining Institute for 1906, and which shows the great advantage of utilizing gas produced direct from coal instead of burning coal in the ordinary way. This interesting, valuable, and comprehensive paper deals with the results of some experiments conducted by the United States Geological Survey Department with different coals on an ordinary steam engine. It was found that it required 3.58 pounds of the best Crowsnest coal to produce one horse-power with this engine, and only 1.68 pounds of Edmonton lignite when reduced to the gaseous form. Similarly it required 3.71 pounds of Blairmore coal, used in the ordinary way, and only 1.71 pounds of Lethbridge coal when reduced to the gaseous form. This shows that by producing gas from the coals and using it, ordinary lignites are twice as efficient as the best bituminous and semi-anthracite coals, burned in the ordinary way. This will open up a great market for the lignites of western Alberta, where the coals can now be so economically used. All who are interested in this subject would, I am sure, find the above mentioned paper by Mr. Dowling of great interest.

NATURAL GAS AND OIL.

There are several likely gas horizons in this district, any or all of which may be gas-producing at favourable points. Medicine Hat gas comes from about the middle of the Belly River or Judith River formation; Langevin gas comes from the same horizon; the Cassils gas is from a higher horizon, just at the bottom of the Pierre. There is also a likely horizon at the bottom of the Edmonton, and one higher in the same formation. Gas or even oil may be found in the Lower Dakota or Kootanie as well,—the Tar sands, found in the Athabaska river, probably correspond to the Dakota.

Though these are the probable horizons at which gas may be found, it can only exist in quantities of economic value in favourable places. As gas and oil are very light they tend to rise until stopped by some impervious strata. It is only where the rocks are arched up in anticlinal form that gas can accumulate; if the rocks are flat, broken, or have a tendency to synclinal form, the gas escapes. In boring, other things being equal, it is, of course, desirable to operate

2

in some valley or other low point so as to get as near to the gas horizon as possible before commencing. The most suitable places are generally along river valleys.

In the western part of the area studied this season the formations are very liable to be too much broken to hold any great accumulations of oil or gas, but along the eastern part of the district conditions for boring are favourable in many places. From the map, sections, and descriptions of the area, the anticlinals can be very closely located and approximate depths calculated to any of the horizons at almost any point on the map.

GENERAL DESCRIPTION OF THE DISTRICT.

East of the area described in this report the country is quite open in most places, and suitable for ranching purposes, but to the west it rapidly becomes more and more rugged and heavily timbered until the main Rocky Mountain escarpment is reached, near the western edge of the sheet. These limestone mountains and their outliers, the Moose and Forgetmenot ridges, have very little timber at all, being much too rugged, except in the valley bottoms and for a short distance above them, to support a growth of trees of any kind.

The valley of the Bow river, to the north of this district, is wide, low and open to the mountains and resembles the country to the east. But immediately to the south of this prairie-like valley the country commences to be more or less timbered, the timber continuing to increase towards the south as it does towards the west, until at the southwest corner of this area, along the south branch of Sheep river, east of the mountains, the country is so densely covered with both standing and fallen trees that it is almost impossible to travel over the hills sufficiently to do either geological or topographical work. There are wagon roads up some of the main rivers for a distance, but it is the Indian hunting trails that are chiefly used by persons wishing to travel through this district.

We travelled from Morley down to Sibbald creek, over the Indian trail running just east of Chiniquy lake. In dry or frozen seasons this is a very fair pack trail, but at other times there are a number of somewhat bad muskegs to be encountered. The hills to the south of Chiniquy lake and around Sibbald creek are about three-quarters covered with small trees, chiefly jackpine, spruce, poplar and aspen, but they are not thick enough anywhere to make walking difficult.

There is a very fair wagon road from Sibbald's cabins on Sibbald creek down Jumpingpound creek to Jumpingpound P.O. On account of a few muskegs, however, loaded wagons would not be able to travel parts of this road in wet seasons.

The low hills to the south of this road and along its western portion are mostly covered with small evergreens, the growth in places being quite thick, but, to the north and east, for a short distance, the trees are chiefly poplar and willow. East and north of this again is the open, rolling, grazing country, which is almost prairie. The hills just north of Springbank Reservoir site are covered with a thick growth of poplar and willow, and the muskegs to the south of it are the most dangerous in the district.

All the valleys here contain considerable areas of muskeg which are generally covered only by grass or underbrush, making it dangerous for stock except in dry or frozen seasons. Generally these muskegs are over the soft, dark shale formations, but sometimes they merely indicate flat dips or low synclinal folds. One such muskeg valley exists about two miles east of Pine Top and North Bragg.

We followed the trail again up Jumpingpound to the head of the creek, for which distance the trail is well travelled and continues along the creek bottom most of the way to its head, where a few more small muskegs were encountered. The valley is rather narrow most of the way and the hills on both sides are fairly high and somewhat rugged, and are over half timbered with green timber,—jackpine and spruce chiefly, with some poplar and aspen. There is also a considerable amount of small dead timber, both down and standing.

Within a mile or so of the head of the creek there are two or three miles of thick, dead, standing timber along the trail, but from here to Cañon creek, the country on both sides is densely covered with evergreens. There are no big trees in this part of the country.

The Moose Mountain ridge, as seen in the distance, consists of bare, rugged, limestone mountains. Coxcomb mountain and the high ridge running thence south to Forgetmenot ridge are also bare and somewhat rugged. The tops of the high hills north of Coxcomb mountain and across Jumpingpound creek from it are bare of timber in most places. Most of the hills to the north and south of Cañon creek, west of the Moose Mountain ridge, are densely wooded with chiefly jackpine, fir and spruce. This country had been mostly burned over a number of years ago, and the timber, which was very thick, has all fallen, and the new growth is very thick and is now quite a size, so that between the down and standing trees it is almost impossible to get over some of the hills at all.

The valley of Cañon creek is wide, and consists, to a great extent, of gravel bars, showing that the creek is subject to great floods. It flows through a deep cañon, through the limestone of the Moose mountains, and from there it continues in somewhat of a cañon to its mouth. This creek is very peculiar in that, although a large creek at all times, there is no water to be seen, except at flood times, in its bed for about

three miles from its mouth,—the water all running under the gravel for this distance. The trout which go up in high water are, therefore, kept in the deep holes in the cañon above, which afford the best trout fishing discovered in the whole country.

The survey was continued south along the Indian hunting trail to the Elbow river, travelling about half the distance through muskegs. The country on both sides is nearly all covered with evergreens of medium size,—with the exception of the summit of the ridge, continuing along east of the trail, which is rugged and free from trees of any kind. A line of small round green hills continues all the way from Cañon creek to the Elbow river, the trail being on the west of the first two, but to the east of the rest.

The river bottom of the Elbow is wide in places, being a quarter of a mile, and is nearly altogether gravel bars, at low water, showing that the river is particularly subject to seasons of heavy floods.

The trail continues south and west up the river, following the river bottom, and crossing and recrossing a number of times, until the limestone mountains are reached. The low hills between this part of the river and the mountains are mostly covered by evergreens; the ridge to the east, however, is high and timbered to near the summit, which is open. The part of the trail going up the Elbow river through the first limestone range to the Kootanie trough to the west is very rough and steep in many places, and passes through considerable timber, which, however, does not extend very high up on the sides of the mountains.

On reaching this trough the trail turns southeast to the head of the south branch of Sheep river and follows down it five or six miles, then crosses the ridges to the west and continues south to the Highwood river. This part of the trail south of the Elbow river has not been used much of late. The valley is quite open, except for a few shrubs and some underbrush. The northern part of this Kootanie basin consists of low rolling hills for about two miles south of the Elbow, but south of this it rapidly becomes more mountainous and for several miles is a very high and rugged ridge, almost as much so as the Palæozoic ranges on each side.

A trail also goes up the Fisher branch and turns south to the Elbow again, as shown on the map. It is somewhat rough but we took horses over it without much trouble. The river bed is wide, flat and gravelly most of the way, as it is farther east. There is, however, a deep narrow cañon about a mile long and about four miles from the mouth of this branch of the Elbow, which has a good well-blazed trail to the south of the river, cut around it,—both ends of the cutting being well blazed on the river. As the timber is very heavy here a great deal of work would be necessary to get around the cañon only for this trail. For

the rest of the way, as far as this trail is marked on the map, horses can travel along the gravel bars at low water. The timber is heavy on both sides most of the way and some cutting has been done in several places, which is a considerable help to travelling. After leaving the Fisher branch the trail turns south and is well marked and easily followed to the Elbow river again.

Another trail continues down the Elbow to the mouth of Bragg creek, but as this follows the river bars and low benches for a great part of the distance, and crosses the river a number of times, it can only be used at seasons of very low water.

The Forgetmenot ridge, as seen from the Elbow river, is very prominent, the eastern part being limestone, the top of which is quite wide and open, particularly to the south of the river for a few miles. The summit of the ridge is along its western side and is a somewhat narrow ridge formed by the conglomerate which overlies the Kootanie coal measures. Between the Forgetmenot and Moose Mountain ridges the country to the south of the river is low and quite open for three or four miles, but to the north it is somewhat more rolling and is thickly timbered with evergreens.

The Moose Mountain ridge, which is also composed of Palæozoic limestones and quartzites, is quite rugged and its hills tower above those of the surrounding country, making them a very prominent feature of the landscape. Just along the Elbow, however, it is not so high and wide as farther north along Cañon creek, where its hills are about as high and rugged as those of the main Rockies.

Prairie Chicken creek flows through a cañon several hundred feet deep for over two miles from the river, and other smaller creeks in the vicinity are somewhat similar, so that this, combined with the heavy timber both down and standing wherever the hills are not too rough for its growth, makes work here somewhat difficult. East of the Moose Mountain ridge the country on both sides of the river is low and rolling, becoming more so towards the east. For four or five miles the hills are all densely covered with small green timber, but farther east the spruce and pine gradually give place to poplar, aspen and willow, and the country becomes more open, especially to the north of the river. For about two miles west of the mouth of Bragg creek the trail practically follows the gravel bars of the river bottom, so that it would be difficult for unshod horses to travel over this trail.

There are some quite extensive hay meadows for two or three miles along the north bank of the Elbow near the western side of range V. These are not used by anyone, are not too wet, and would be valuable if easier to reach. However, during the dry months a wagon could easily drive to them by following the wagon road from Robinson's cow camp on the north branch of Fish creek, up to about a mile west

of the Sarcee fence, then going north to the Elbow river over a level, open piece of country and from there following up the wide level river flats. Along this part of the river the water is low enough in the summer months to allow a person to drive across it safely and easily at almost any point. It would be difficult, however, to take a wagon up the Elbow by following the river from the mouth of Bragg creek.

There are also valuable hay meadows north of Bigmeadow, to which the wagon road up the north branch of Fish creek is built, but the hay is cut here every year.

There was formerly a wagon road also up Bragg creek to the Thorne mine at its head, but now, with the exception of about the first two miles, it is only a trail and hard to find, at that, in most places. There is a particularly bad muskeg about three miles from the mouth of the creek, but this is avoided by following the creek bottom for a short distance. It is quite open on both sides of Bragg creek for about four miles from the Elbow, except for a few patches of poplar, willow, &c., here and there. Long grass grows everywhere and it is particularly suitable for ranching here, except for the muskegs; however, cattle seem to avoid them fairly well, as a rule. The only safe times for rounding up the stock, though, are in the early spring and late autumn when the ground is frozen. This is the western edge of the ranching country here.

North Bragg is quite open as is also South Bragg opposite it; but most of the country to the west of this is densely wooded with pines, spruce, &c. There is very little poplar or willow in this vicinity. For about two or three miles east of the Thorne mine there is some fairly valuable timber, the growth being very thick and the trees being larger than seen in most places this season.

Another trail from Morley crosses Jumpingpound creek near the Springbank Reservoir site. This far it is good; but from here the Indians generally travel south through the muskeg valley west of James Greyson's to Bragg creek. To persons not perfectly familiar with the trail it is much better to take the wagon road shown on the map, passing through Mr. Greyson's place to the Elbow river and thence south as shown. The Sarcee reserve was fenced on all sides with barbed wire fencing this summer and, as there are gates only on the main wagon roads, the trails go around the outside of the fence now. From the Elbow river to the south branch of Sheep river this is a good, well travelled trail and easily followed.

The hills for three or four miles east of Bigmeadow are about two-thirds covered with a thick growth of poplars, aspens, and willows. Robinson and to the east is somewhat more open. Topknot and Bigmeadow are only partially covered with trees, these, however, being nearly all evergreens. The hills to the north of this portion of Fish

creek are low and rolling; but to the south of the creek the country is much rougher and the hills much higher and more rugged and much more heavily timbered. Practically all the trees are evergreens to the south of the portion of this creek shown on this map. Rock Point, and the hills for four or five miles to the east, rise quite abruptly from the south bank of the creek, forming quite a contrast to the low, flat country to the north. The valley of the south branch of Fish creek west of the end of the wagon road continues to be wide, low, and flat in many places, but is often covered with trees and underbrush and there are a few muskegs, making it difficult to travel with horses. Portions of it, however, are quite open, and with the wide open valley running up to the Elbow, just west of Topknot, might be valuable for ranching purposes.

From the mouth of Fisher creek good wagon roads (see map) run up to John Quirk's place, which is the farthest ranch up the river. This valley is particularly adapted to ranching, having extensive hay meadows, and the valley itself being somewhat wide and the surrounding hills low and only partially covered with poplars, aspens, &c. But what is most noticeable is that no muskegs were seen; the valley appears to be free from them. A wagon road also runs up Ware creek, locally known as Sinnot creek, to south of Sinnot 2. The valley of this creek to the end of the road is wide and open; but above this it becomes narrow and heavily timbered, chiefly with evergreens. The hills to the south of this creek up to Gleason creek are thickly covered with timber, chiefly spruce and pine, there being no open places except some patches on Gleason, which are too rocky for plant growth. The upper parts of Sinnot 1 and Sinnot 2 are sparsely covered with poplar, the surrounding valleys being completely covered with poplar interspersed with fallen spruce and pine. From here along Death's Head ridge, the pine and spruce growth increases, though it has nearly all been recently burned over and much of the timber is down. Death's Head itself is quite open. Along the south side of Ware creek there is also considerable poplar and aspen. The south side of the ridge running from Death's Head to Volcano, also of ridge from Volcano to Allsmoke and Gleason Meadow has been burned over, and a young growth of pine now covers it here and there. Nearly the whole country west of Gleason and Missing Link to the Rocky escarpment is completely covered, and generally thickly and heavily covered, with evergreens. The top of Ware Head, however, is a high rocky summit several hundred feet above any timber.

The trail running up Ware creek and down Gorge creek to the south branch of Sheep river is a very fair one except in wet seasons, when the muskegs at the head of Ware creek might give some trouble. The greater part of the hills to the south of that portion of the north

branch of Sheep river from the mouth of Ware creek to south of Mesa Hill is heavily wooded, there being more evergreens than poplar and aspen. The northern side is only sparsely covered here and there with chiefly poplar. Mesa Hill, Lowndes, and those hills to the east and north, and the valleys in between them, are covered with a dense growth of spruce, pine and poplar, except the summits of the hills, which are quite open. From about a mile west of Mesa Hill following along the south side of Barwell ridge and west to Nichi the country is mostly heavily covered with spruce and pine; towards the east, however, are some poplar and willows close to the river. The top of Nichi is burned over and is quite open. On the south side of the river the hills have a comparatively thin growth of pine, beginning about two miles east of Allsmoke, but that portion west of Mesa Hill has been partially cleared by fires. The northern slope of Allsmoke and the country from there to the limestone is thickly timbered, chiefly with pines. The greater part of the valleys of Threepoint and Volcano creeks is densely wooded, but the muskeg, and the country west of the head of Threepoint creek west to the Elbow river, is quite open.

The trail from John Quirk's place up the river to the mouth of Muskeg creek is very good, but above this there were no signs of any one having travelled this way for years. In a place or so parts of an old trail could be seen, but the great amount of fallen trees would have necessitated five or six miles of heavy cutting to have got horses over to the Elbow river this way. North of Death's Head the river valley narrows up considerably, and at the mouth of Muskeg creek it becomes a gorge with almost perpendicular walls and remains so up to the falls,—just below which the gorge is 390 feet deep and is about the same in several other places. Above the falls for about a mile the banks of Threepoint creek are steep, grassy slopes, partly covered with timber. West of Nichi the valley again closes in and deepens and a cañon with sides chiefly of limestone talus extends through the Forget-menot ridge.

A good wagon road, except in very wet seasons, goes up the south branch of Sheep river to the logging camp north of Hoffmann mountain. From here a good pack trail continues up the river to connect with the trail running south from the Elbow river, west of the first limestone range of the Rockies. Going through this most easterly range of the mountains proper the trail is very rough, crossing the river a number of times.

Sheep river flows through what is practically a cañon 50 to 300 feet deep nearly the entire distance from the mouth of Macabee creek west to the logging camp, above mentioned, and as nearly all the creeks running into it have formed cañons near the river as well, travelling becomes somewhat difficult along the river, and the wagon road up it for this reason follows up Macabee creek for several miles.

To the north of the mouth of Macabee creek the hills are quite open, but towards the west the country becomes gradually covered for three or four miles with poplars and aspen, which are then gradually replaced by a more or less heavy growth of pines to Lower Camp. West of this on both sides of the river to the Rocky escarpment the country is densely wooded. Darkie and the hills to the east are only partially covered with timber, chiefly pine, but west of this there is a very heavy growth of evergreens everywhere.

Along the river, for about four or five miles north of Greenslope, the river flows through a dark shale cañon with almost perpendicular walls 100 to 200 feet high. Up Gorge creek this cañon continues for about three miles, with an average depth of over 200 feet.

The tops of Junction and Hoffmann are the only open points practically in this part of the country, except some open flats along the north of the river, close to the top of the cañon and just west of Lower Camp.

GENERAL GEOLOGY.

In the portion of the Foothills worked this season the following formations were studied:—

Edmonton formation.	
Bearpaw shales.	
Judith River beds.	
Claggett shales.	Cretaceous.
Niobrara-Benton.	
Dakota beds.	
Kootanie formation.	
Fernie shales.	Jurassic.

Devonian and Carboniferous limestones and quartzites.

The Edmonton Formation.

The *Edmonton* formation consists of light-coloured, soft, sandstones, shales and clays, usually fairly well bedded and frequently alternating. The sandstones predominate, are often thinly bedded, occasionally quite hard, and at times weather to a yellow colour; gray or brown shades are, however, rather more common. The shales and clays are gray, yellow, grayish-brown, bluish-gray, or even quite blue or pale green in colour. Molluscs are quite plentiful. There are at least two coal horizons in the Edmonton, one near the base and the

other somewhat higher up. This formation corresponds to the lower beds of Dr. Dawson's St. Mary River beds which he placed at the bottom of the Laramie. This term Laramie, however, has become so indefinite and unsatisfactory that in this classification it is omitted. The Edmonton is here considered to form the top of the Cretaceous and the beds above this are placed in the Tertiary. In the area worked this season we were unable to find a complete section of the Edmonton which could be satisfactorily measured, so that its thickness was not determined for this district. It is a fresh-water formation, becoming brackish towards the base.

Bearpaw or Pierre-Foxhill.

As Foxhill fossils are found at different horizons in the Pierre, and, in fact, seem to be distributed throughout it, and as the Pierre and Foxhill rocks are in most places so intermingled as to cause the latter term in this locality to be too indefinite to be of value, in this report no attempt has been made to draw a line between them or to separate the Foxhill rocks, and both these and the Pierre are included under the name Pierre or Pierre-Foxhill shales. These consist of dark gray to brown or even, in places, nearly black, shales or shaly clays of a very uniform appearance. Somewhat coarser and lighter coloured sandy shales and sandstone bands occur at uncertain intervals throughout the formation. At times these are quite prominent, but often they are hardly noticeable unless the formation is closely examined. The more prominent sandstone beds are usually near the centre. At the top and bottom the dark shales grade into the overlying and underlying light coloured sandstone fresh-water series. These shales are essentially marine. A great many ironstone bands and nodules occur throughout them.

These shales are somewhat difficult to measure except in places where the formation is quite regular, because when there is any disturbance at all these soft pliable rocks become much more easily folded and broken than the sandstones above and below them; also on account of their very uniform appearance, with few or no horizon markers, irregularities are difficult to solve. This formation was, however, measured in a few places and the thickness in each case was near 650 feet, which was the average.

A carbonaceous horizon exists near the base of these shales, but in this area no coals of economic value were noticed here.

Considerable difficulty has been experienced by geologists both in western Canada and in the western States by finding Pierre shales both above and below the Judith River beds. This has caused the

latter to be assigned to different horizons. Recent study has shown that marine and fresh-water conditions have so alternated as to cause the Judith River formation to exist somewhat in the form of a wedge in the Pierre. Variations in the thickness and characteristics of the Judith River beds and in those of the Pierre and in the relative portions of the latter above and below the former, have added considerably to the difficulties in the study of this part of the Cretaceous section.

In Bulletin 257 of the U. S. Geological Survey published in 1905, Messrs. Stanton and Hatcher have given a detailed history and correlation of the Judith River beds.

To avoid confusion they have called that portion of the Pierre shales lying above the Judith River beds the Bearpaw shales, and that portion below the Claggett shales. So, for convenience, I am adopting these names in this report.

Judith River Beds.

The formation designated as Belly River was in 1875 correlated by Dr. G. M. Dawson with the Judith River series of Missouri. These are the same beds which in 1874 he had called Lignite Tertiary. Recent investigation has proved this correlation of the Judith River with the Belly River beds. Attempts have also been made to correlate these with the Dunvegan sandstones of the Peace River country.

This series underlies the Bearpaw and consists of light coloured sandstones, shales and clays,—very similar in some respects to those of the Edmonton. However, in this area the molluscs which are quite plentiful in the Edmonton are almost entirely missing in the Judith River beds, especially the *Ostrea glabra*,—not one specimen of which was found in the latter beds, but were very plentiful in the former. Also remains of plants, leaves, tree-trunks, &c., are quite plentiful in the Belly River beds. One thick, white, rather massive sandstone bed, in particular, was noticed in several localities which afforded numerous specimens of tree trunks, often up to eighteen or twenty inches in diameter. These white sandstone strata, often cross-bedded, are very characteristic of this formation. Yellowish, gray, blue and greenish-gray shales and clays are common, often becoming quite hard. A few brownish shale beds were occasionally seen. Brown, gray and yellow weathering sandstones predominate.

This is essentially a fresh-water formation, but it becomes brackish towards the top and bottom. Even marine beds have been detected in some localities in this horizon. The maximum thickness of these beds, where measured, was 1,025 feet, measured along the Bow river. Farther south a good section was obtained, but the formation here was only 850 feet.

Claggett formation.

These shales correspond to Dr. Dawson's Lower Dark shales and are really a lower portion of the Pierre; but for convenience this name Claggett has been adopted for those dark Pierre-like shales immediately underlying the Judith River beds. They contain a fauna formerly considered as being chiefly Pierre or Foxhill. In the western States where the Niobrara limestones are easily identified these Claggett shales are easily distinguished from the Bearpaw and Benton, but when the Niobrara is absent or not sufficiently prominent to be identified the distinctions between Bearpaw and Claggett can be made only when their position relative to the Judith River beds can be definitely ascertained. The fossils help to some extent, but being so similar they are only of value in this instance when extensive collections can be made.

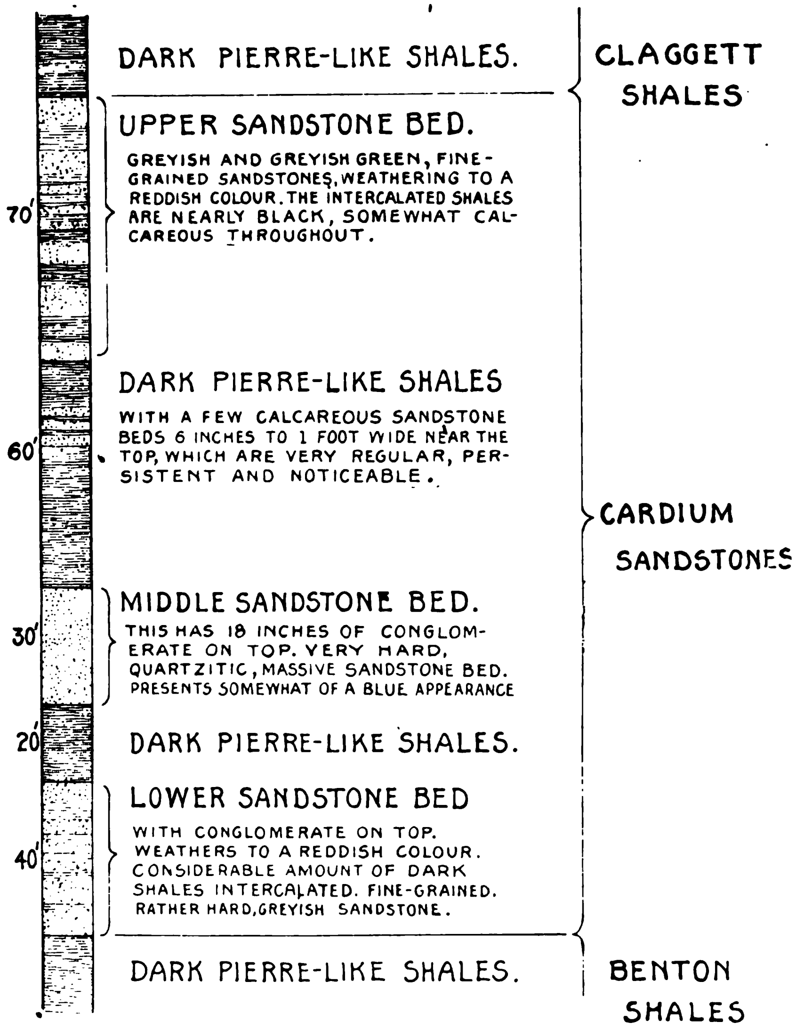
Below the Judith River beds in this portion of the Foothills are 150 to 300 feet of dark shales followed by a sandstone series 50 to 150 feet thick, which overlies, again, 500 to 800 feet more of dark shales lithologically similar to the Pierre and Claggett. The upper 150 to 300 feet stratigraphically and lithologically can be correlated with the Claggett. Also the few fossils found bear out this correlation, such types as *Baculites compressus* being somewhat common. At the bottom of this upper portion of the black shales are several calcareous bands from a few inches to one foot in width and the shales here become somewhat calcareous as well. The sandstone series which immediately underlies these is most prominent on the Bow river and consists of three sandstone bands separated by, and somewhat intermixed with, the dark shales. One or each of these sandstone bands is sometimes capped by conglomerate, which has at times been mistaken for the conglomerate overlying the Kootanie coal measures. Since portions of this sandstone series, as well as the upper part of the shales below, are quite calcareous, and since Colorado fossils are quite plentiful in both the sandstones and the shales, it appears practically certain that the calcareous rocks correspond to the Niobrara and the shales below to the Benton, so in this report the sandstone series with the dark shales below are included under the name Niobrara-Benton. So that in the work this season the Claggett could be only distinguished in the field from the Benton shales where fossils were found, or where the sandstone series between them was of sufficient prominence to be identified; and the Claggett could only be distinguished from the Bearpaw when their positions relative to the other horizons—such as Judith River or the sandstones series between the Claggett and Benton—could be determined.

Specimens of *Cardium pauperculum* are so plentiful in this sandstone series that Dr. Hector, in 1858, called the whole shale series

along the Bow river, including the Claggett and Niobrara-Benton, the *Cardium* shales. Farther south this sandstone series, which for convenience I shall call the Cardium sandstones, is not so prominent, being only about fifty feet thick and the characteristic associated conglomerates are only occasionally seen, so that what is such a good

SECTION OF THE CARDIUM SANDSTONES MEASURED NEAR OLD BOW FORT, ON THE BOW RIVER.

BENTON SHALES.



and reliable horizon marker along the Bow river ceases to be of much value as such along the south branch of Sheep river. As, for these reasons, it would require considerable detailed work to accurately map the Claggett and the Benton separately, except in a few localities, on the map to accompany this report, the Claggett shales, the Cardium sandstones and Benton shales are given the one geological colour.

The Eagle formation, which is so well developed along the Missouri river, has not been identified as yet in western Canada. Messrs. Stanton and Hatcher are of the opinion, however, that certain rocks referred by Dr. Dawson to the Belly river belong to this series. In Bulletin 257 of the U. S. Geological Survey, they say: "The castellated sandstones along Milk river between Verdigris coulee and Dead Horse coulee, as described on page (*a*) 40 C and as figured (*b*) in an earlier report, resemble the Eagle sandstone much more closely than any part of the Judith River or any other horizon in the general region. This same sandstone horizon was recognized in Rocky Spring ridge and on the west flank of West butte (Sweetgrass hills) resting on dark shales, which, at the last named locality, have an estimated thickness of 800 feet. Now this thickness is much too great for the shales of the Claggett formation, which underlies the Judith River and is the same as that of the Fort Benton shales beneath the Eagle."

In this portion of the Foothills covered by this report the Cardium sandstones correspond stratigraphically to the Eagle formation and one or more of these beds might be correlated with it, but sufficient evidence was not obtained this season for so doing.

Benton shales.

These are the dark marine shales which occur below the Cardium sandstones and have a thickness of from 500 to 800 feet. They correspond lithologically with the Bearpaw and Claggett, and, except where the Cardium sandstones are to be seen, no line can be drawn between them and the Claggett. These shales, being somewhat soft and pliable, are easily folded and distorted, and it would, therefore, require a great amount of detailed work to map the Benton and Claggett shales separately, so, as explained above, in this map they are given the same geological colour. As these dark shales weather very easily their outcrop tends to become a valley, and on this account their exposures would often be very difficult to find only for the Cardium sandstones which are very hard and whose outcrops form the summits of hills and ridges, very often, so that the shales are then known to be on each side.

(*a*) Geol. Surv. Canada, Rept. Prog. for 1882-1884.
(*b*) Rept. Progress for 1880-1882, frontispiece of Dr. Dawson's report.

Dakota formation.

The Niobrara-Benton formation rests on a sandstone formation which, taken as a whole, presents a greenish-blue appearance. The upper beds consist of light coloured sandstones, shales and clays, somewhat similar in a few respects to a portion of the Judith River beds,—but they are harder and finer grained and present a greater variety of colour, and are somewhat darker. Greens, blues, and grays are the most noticeable colours, but there are also a few very persistent red bands about two feet wide, which occur near the top of the Dakota and form good horizon markers in certain localities. The rocks of this formation are well bedded and are chiefly fresh water, particularly the upper light coloured beds.

Below these upper beds are some which are darker and harder, which in turn over-lie some coarser, lighter-coloured, and somewhat more massive, beds of sandstones. These again are followed by 300 or 400 feet of thinner, harder, darker strata. The sandstones, which are very hard and often quartzitic, frequently are seen projecting in ridge-like form beyond the shales on each side, which, being softer, weather much more rapidly. This is particularly noticeable near the logging camp on the south branch of Sheep river. The shales here are very dark and occasionally quite black. The sandstones as a rule present the general appearance of a dark green or greenish-blue colour. Below these again are a few thicker beds of sandstone which are very fine grained, quartzitic, and gray in colour; the lowest one being very noticeable and almost white in colour, and averaging from ten to fifty feet in thickness. This latter bed is very persistent and was traced for over thirty miles, nearly the entire distance from the Bow river to the south branch of Sheep river. Below this is the conglomerate forming the base of the Dakota. This gives a total thickness to this formation in this area of from 900 to 1,700 feet. This conglomerate is the best horizon marker in the whole area covered this season, extending from about five miles south of the Bow river to past the southern edge of this district, and maintaining its characteristics throughout. It is generally from ten to thirty feet in thickness and consists chiefly of cherty and milky pebbles, generally not very large, averaging from the size of marbles up to hens' eggs. Occasionally it is somewhat iron stained, but usually presents a somewhat milky-blue appearance. The pebbles are held together by a hard siliceous cement.

This represents a shore line running just east of the Rockies for this distance, and it probably extends for many miles to the south. As this conglomerate is so hard its outcrop forms the summits of most of the hills and ridges where it is found, and as the Kootanie coal measures lie immediately underneath it is very valuable to persons looking for

coal, and is, therefore, often referred to in this report as the *Coal Conglomerate.*

The Dakota formation also seems to correspond very closely with the Flathead beds as observed farther south and inside the mountains. However, from the evidence furnished by quite an extensive collection of plant remains gathered this season, it would seem quite possible that the dark lower beds of this series might be Kootanie. This would make the Dakota thinner and the Kootanie thicker, and so nearer the relative thicknesses shown within the mountains. I have taken the conglomerate, however, as the dividing line between the two formations, not only because it is a good horizon marker, and so a convenient dividing line, but also because from a close study of the rocks there is readily seen to be a decided difference lithologically in the formations above and below it.

The Kootanie formation.

Mr. McEvoy, in the Summary Report of this Department for 1900, gives a section on the Elk river of the Crowsnest coal fields proper, of which 3,290 feet are likely Kootanie rocks. These contain 216 feet, two inches of coal. Of this thickness of coal, however, 198 feet occur in 1,847 feet of measures. In the Summary Report for 1902, Mr. W. W. Leach gives sections of the Blairmore-Frank coal fields, which are east of the above coal fields and separated from them by the main range of the Rocky mountains. On Cat mountain, on the western flank of the Livingstone range, the coal measures beneath the nine feet, six inches of conglomerate are only 732 feet, six inches thick, with a total of 125 feet, three inches of coal. Just inside the first limestone range, at the head of the south branch of Sheep creek on P. Burns' coal property, about forty-four feet of coal was all that could be found. East of the Rockies in this portion of the Foothills the average thickness of the Kootanie coal measures found was about 340 feet, containing from twenty-one to twenty-six feet of coal. This shows that the Kootanie coal measures are rapidly thinning out towards the east, and do not likely extend past the edge of the disturbed Foothills region. Until this season it was not known that they extended into the Foothills at all.

The strata between the conglomerate at the base of the Dakota and the dark shales of the Fernie below contain all the coal seams discovered below the Judith River beds, and they stratigraphically and lithologically correspond to the Kootanie formation as found inside the mountains. At the top is usually a coarse, dark sandstone bed, ten to thirty feet thick. Below these are chiefly dark shales and sandstones, presenting a general brownish appearance. Interbedded with

these are the coal seams. Below these is a very prominent and persistent hard sandstone bed, thirty to seventy-five feet in thickness. This weathers to a peculiar yellow colour, similar to that often seen on limestone. The faces of its bedding planes are also always pitted in a peculiar manner; but it is not at all calcareous. A fractured surface always presents a brown to an almost black, fine-grained appearance.

The fossils, chiefly plants, found in this formation in different localities, point very strongly to the possibility of its being Jurassic and not Cretaceous, as has been previously supposed. The Fernie shales, which lie immediately beneath, have been proved by Mr. T. W. Stanton, and others, to be Jurassic; and in this region in the Foothills no evidence of an unconformity or any lapse of time exists between the Kootanie and the Fernie shales (in fact they gradually change into one another); and it would seem possible that the conglomerate at the top of the Kootanie might mark a slight time hiatus, particularly as the rocks above and below are so entirely different in character,—both in colour and in the character of their components. So for these reasons I would consider it very probable that the coal measures, as well as the Fernie shales, are Jurassic, and that the Dakota, in this region, forms the bottom of the Cretaceous.

Fernie shales.

Immediately below the brown sandstone bed at the bottom of the coal measures are thin-bedded brown sandstones and dark shales, grading down within a few feet to black, fine-grained, finely bedded clay shales, which are rather hard and slaty in most places. Fossils are somewhat scarce in these shales, but in one place Belemnites are very plentiful. These dark shales in this district are from 100 to 250 feet thick, having, like the Kootanie rocks above them, become much thinner towards the east than inside the mountains.

DESCRIPTIVE GEOLOGY.

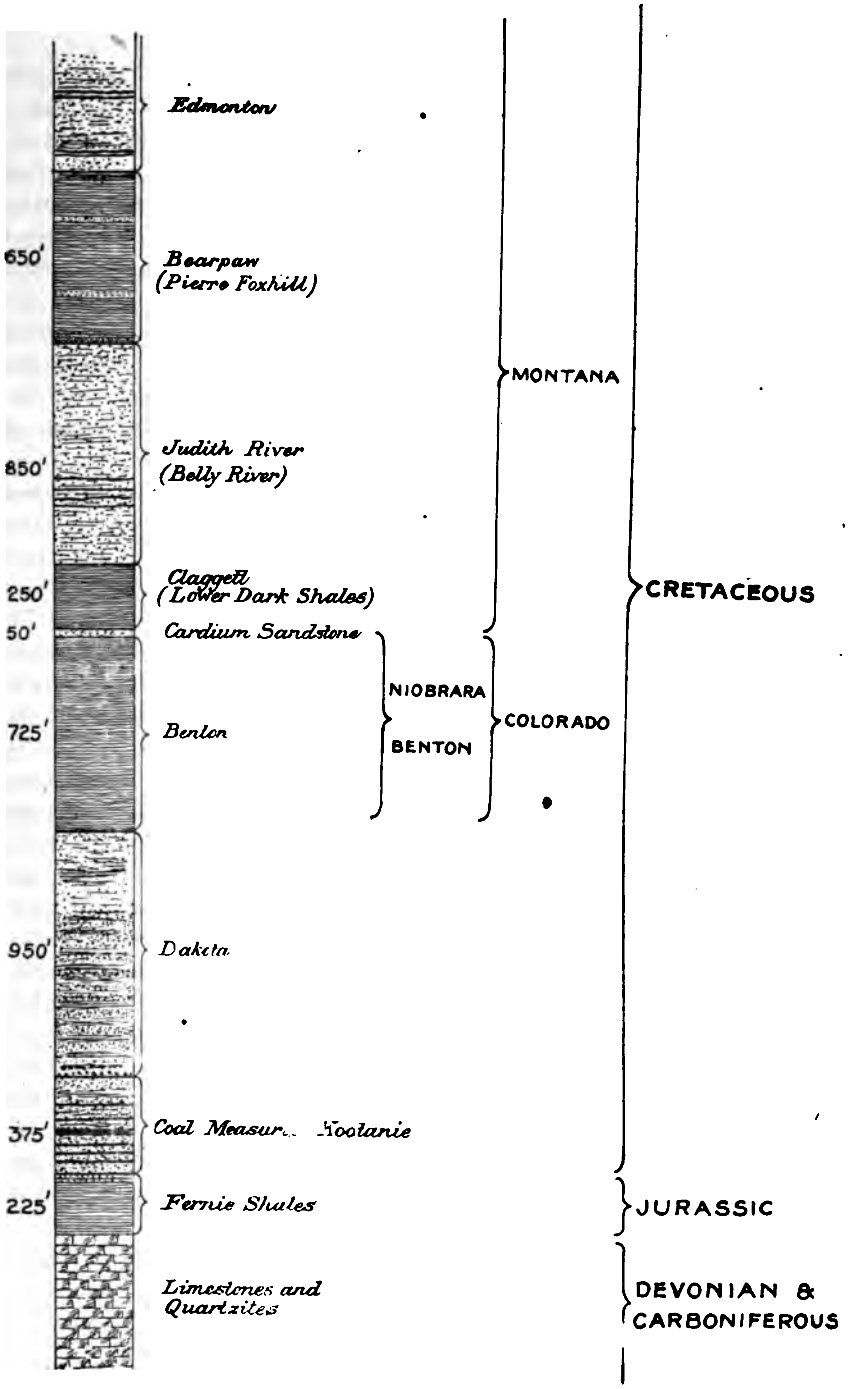
General Outline of the District.

The contact between the Palæozoic and Cretaceous is a faulted one,—the former having been pushed over the latter for several miles, in most places the fault plane dipping west, usually at low angles. It is these Palæozoic limestones and quartzites, next the Cretaceous, which form the eastern escarpment of the Rocky mountains, immediately east of which is the Disturbed Foothill region, that portion of which

lying between the Bow river and the south branch of Sheep river is dealt with in this report.

Enormous and long continued pressure from the southwest has caused the geology of this district to be often very irregular, the rocks being all more or less folded and the folds usually pushed over and often faulted. The high, rugged, Palæozoic ridges,—the Moose and Forgetmenot, somewhat to the west of the centre of this area, are the most marked results of this pressure, and form not only the most prominent topographical features of this district, but are also the most interesting geologically. They are really just immense folds. The mountains of the Moose Mountain ridge form an anticlinal ridge, or rather a quaquaversal of limestones and quartzites, having the Fernie shales overlain by the Kootanie rocks lying on them and dipping away on all sides. Just west and south of this limestone ridge is another,—the Forgetmenot ridge, narrower and less prominent than the first and formerly mapped as being connected with it, but at their closest points they are separated by about one and a half miles of Cretaceous and Jurassic rocks. This latter ridge is not as regular as the more easterly one, being faulted nearly its entire length along its eastern side; but along the western edge and at the north and south ends the Lower Cretaceous strata are exposed.

It was by working around these ridges that our expectations of finding the Lower Cretaceous, and thus having a section in the Foothills of Alberta from the Carboniferous to the Tertiary, were realized. The overlying Cretaceous strata were upraised with the Palæozoic rocks of these ridges, and now, after long periods of erosion, the Lower Cretaceous rocks appear with upturned edges high up on the sides of these limestone mountains, entirely encircling them, with the exception that along the eastern side of Forgetmenot ridge the pressure was too great and the fold was broken, causing the limestones to be pushed over the Cretaceous rocks, in a similar manner to that along the contact east of the main Rocky Mountain escarpment. Thus, these two ridges afford an excellent opportunity for studying the Cretaceous, a complete section being exposed commencing with the Kootanie and passing up within a few miles into the Edmonton. The thicknesses of these beds were measured in several places, about an average section being obtained just south of the Forgetmenot ridge, on the north branch of Sheep river.


Edmonton
650'
Bearpaw
(Pierre Foxhill)
850'
Judith River
(Belly River)
250'
Claggett
(Lower Dark Shales)
50'
Cardium Sandstone
725'
Benton
950'
Dakota
375'
Coal Measures Kootanie
225'
Fernie Shales
Limestones and
Quartzites
MONTANA
NIOBRARA
BENTON
COLORADO
CRETACEOUS
JURASSIC
DEVONIAN &
CARBONIFEROUS

Bow River Section.

On the map to accompany this report is shown a "Bow River section" from the mountains to a short distance east of the mouth of Jumpingpound creek. This section is measured true east and west, the outcrops being those observed chiefly along the banks of the river and projected on this east and west line; so that distances between points along this section are the distances the points are east and west from one another and consequently somewhat less than the actual distances as measured along the river.

The disturbed area of the Foothills extends along the Bow river from the mountains east to the mouth of Coal creek. East of this the formation is quite regular but the hills are somewhat rolling for a distance, forming what may be regarded as the northern extension of the Porcupine hills.

At the mouth of Jumpingpound creek characteristic sandstones and shales have a slight easterly dip of 5° to 10°. East of this, to the end of the section, the formation has a slighter dip, becoming almost flat south of Cochrane station, where the rocks are Upper Laramie, or what Dr. Dawson called the Porcupine Hills series.

West of Jumpingpound to the mouth of Coal creek the Edmonton rocks continue to dip quite regularly, increasing the angle of dip to about 28°,—just east of the mouth of the creek. These rocks are light coloured, soft sandstones, clays, and shales, usually of very pale brownish or yellowish shades; some light gray sandstones, however, outcrop as well. The shales and clays at the mouth of Coal creek are pale yellows, blues and greens. Molluscs are of frequent occurrence in these sandstones,—*Ostrea glabra* being very plentifully found at several places. At the mouth of Coal creek are also the coal seam and old mine workings described above. For about a mile west of here the rocks show considerable disturbance, exhibiting a series of folds accompanied, to some extent, by faulting. Thence to about two miles west of Morley bridge,—a distance of approximately fifteen and a half miles along the river, the dips, as seen on the river banks, are with only slight exceptions, all to the west; as the horizons are becoming lower this may, at first, appear strange, but the change is caused by reversed folding. Some faults were noticed west of Coal creek, but they are only of minor importance and are thrusts with eastern downthrow of only a few feet.

Between Coal creek and the mouth of Ghost river two dark shale Bearpaw belts are seen. The more easterly one shows only the top of an anticlinal fold, rising only a few feet above the water and having the Edmonton sandstones overlying the dark shales composing it.

For about three miles west of Ghost river the rocks are considerably disturbed and those of the Pierre-Foxhill, Edmonton and Judith River formations are very much interbanded and so intermixed in places that they are exceedingly difficult to distinguish from one another. The fossils found were all those of the Pierre-Foxhill types. Three dark shale Pierre bands were recognized in this distance, between which are chiefly Judith River strata. In places are narrow sandstone beds, often about ten to thirty feet thick, interbedded with portions of these Pierre shales of about the same thickness, showing that these formations are very considerably squeezed together. The section shown is somewhat diagrammatic here, being too small to show this close interbanding, and showing only the main folds.

At a bend in the river about four and a quarter miles above the mouth of Ghost river the first Niobrara-Benton rocks are seen. Here the Cardium sandstones are quite prominent and each of the three sandstones is capped by conglomerate beds varying from a few inches in thickness to ten or twelve feet. On the hills just north of the river two bands of the conglomerates from ten to twelve feet wide were observed. Specimens of *Cardium pauperculum* are very plentiful in these sandstones. From here up the river for about two and a half miles, to a few hundred feet above Morley bridge, these dark shales with the Cardium sandstones outcrop continuously, either on the river banks or in the hills to the north. The sandstones and conglomerates cross the river twice above the bend in the river above referred to,—the second crossing being just at the Morley agency. Pierre fossils, such as *Baculites compressus*, occur in several places in the Claggett shales, and Benton types, as *Inoceramus problematicus* and *Scaphites ventricosus*, occur in the shales below.

Up the river, from the most westerly point above described, for about half a mile the Judith River rocks outcrop, overlying the Claggett, and are here noticeably white in colour. A thrust fault, with small throw, again brings the dark shales to the surface for a few feet and then for two miles there is a low flat syncline of Judith River beds, from the western edge of which, to within a mile of the Palæozoic contact, the Claggett, Benton and Cardium sandstone formations occupy the river bed,—the outcrop in the banks being almost continuous. Here the upper and lower series of dark shales can readily be distinguished from each other by stratigraphy on account of the prominence of the intercalated sandstones. The shale formations are lithologically almost identical,—the lower being, however, considerably the thicker. For this distance these formations are in the form of a very flat syncline, similar to that observed in the country to the south of the river,—the whole central portion of the fold being approximately flat and undulating. East of Old Bow fort the Cardium sandstones

outcrop for over two miles along the river and are practically flat for nearly the whole distance.

The Kananaskis falls, at the mouth of the Kananaskis river, are caused by these sandstones. The upper bed is above the falls proper and gives rise to a rapid. The other two outcrop below the mouth of the river and cause the greater part of the falls. These sandstone beds dip to the west at about 20° and the water falls over their hard projecting edges. The lowest bed is a very hard sandstone weathering to a reddish colour, and is fairly well bedded. The sandstone next above is gray in colour on a freshly fractured surface, is very massive, thick, hard and even quartzitic. There is a conglomerate bed about one foot thick on top of each of these two lower sandstones. The upper sandstone is here also quite hard, and weathers to a reddish colour. The Judith River beds, overlying the upper shale series, *i.e.*, the Claggett, to the west of here, can be seen reaching high up on the eastern side of the mountains which form the eastern escarpment of the Rockies; and they continue so for about twenty miles to the south of the Bow river.

The formations north from the north end of the Moose mountains are in the form of a wide east and west anticline, dipping down to the north, to such an extent that by the time the Bow river is reached, just west of the Kananaskis, the Benton shales are the lowest rocks outcropping even at this very low elevation of about 4,000 feet above sea-level; whereas, only eight or nine miles to the southeast, Kootanie rocks and Fernie shales, over 1,000 feet lower down, outcrop on Coxcomb mountain at an elevation of about 7,000 feet. This shows the structure of this whole area to the northwest of the Moose mountains to be in the form of a toe pointing down to the north and bending over on each side to the east and west. This same thing also occurs, although not quite so noticeably, on all sides of the Moose Mountain ridge, which in this way influences both the geology and topography of almost the entire area described.

Jumpingpound Creek.

Going up Jumpingpound creek from the mouth of Little Jumpingpound, the two dark shale belts running north from the Elbow river are seen to outcrop, as shown on the map. On account of scarcity of outcrops,—the hills being low and deeply covered with wash and drift,—these belts were not traced past the points shown, although they may extend farther north than is shown and may be somewhat wider at their northern ends. West of these is the low flat syncline of Judith River beds which is here about eight miles wide and composed of light coloured sandstones, shales and clays, the sandstones often almost

white and generally soft and easily weathered. Ironstone nodules are quite plentiful in many places. For the whole central portion of this belt the formation is somewhat wavy, but is, on the whole, practically flat. A section from its western edge east to the edge of this map would be very similar to the one shown along the Elbow river, except that the western sandstone belt is so much wider.

To the west of this syncline come the dark shales again, which are here about two and a half miles wide on account of considerable folding and disturbance, but have their main dip to the east. The folds can here be traced fairly well as the Cardium sandstones are rather prominent and make good horizon markers. These shales were originally folded over the anticline of Dakota rocks to the west, but the upper portion of the fold is entirely eroded away. This Dakota formation here is composed of brown, red and gray sandstones, and bluish, yellow, green, brown, red and black shales and clay; in fact, this is a very highly coloured, though somewhat dark series. The sandstones are mostly coarse, but are generally rather hard, and, at times, both these and the shales are very fine-grained and extremely hard and quartzitic,—almost as much so as the Cardium sandstones. The upper rocks are very characteristically green and blue with a few red bands. The beds of this anticline dip rather abruptly to the east and west, but the central portion of the fold is almost flat in an east and west direction, being only slightly undulating. To the west of these Dakota rocks the dark shales again appear, overlying them, but are here somewhat narrow, being quite regular, and have a regular dip to the west. The Cardium sandstones are well defined along the creeks cutting this formation and specimens of *Cardium pauperculum* are here very plentiful in them, as to the north. West of this belt the Judith River beds overlie the dark shales of the Claggett and dip to the west also with decreasing angle of dip until next the fault line between them and the Palæozoic; their angle of dip nearly coincides with that of the fault plane, which is here about 23°.

The hills to the north and south of Jumpingpound creek, where it is passing through the anticline of Dakota rocks, are high and somewhat rugged with dips to the north and south down to the creek from the south and north sides respectively, so that the creek is flowing in a natural channel, somewhat deepened, of course, by erosion and glaciation. The Kootanie rocks near the top of Coxcomb mountain dip to the north down over the face of the hills so rapidly that they outcrop in the creek bottom, nearly 2,000 feet below and only about a mile distant. Those seen in the creek, however, are Upper Kootanie and no coal of importance outcrops.

Along the upper part of Sibbald creek, and also along a small creek flowing into Lusk creek from the east and heading at about the

same place as Sibbald creek, a splendid section of the Dakota is exposed, the hills rising quite abruptly for nearly 1,000 feet in places, both to the north and south of the heads of these creeks. A somewhat thick, red, coarse sandstone bed about fifty feet thick is noticeable here. Many of the shales and sandstones are very hard, being very different from those seen east of the mouth of Sibbald creek.

The shale belt to the west of here is represented topographically, for the greater part of the thirty-five miles in length of its outcrop, by a valley, or more often by low hills,—the soft shales weathering easily, the Cardium sandstones being harder and forming the axis of a ridge or line of hills. These sandstones are very helpful in tracing and locating the shales as their outcrop is easy to find, and the dark shales are then found on each side of them.

Following up Jumpingpound creek to its head and continuing in a southerly direction to Cañon creek, up Trail creek and down Ford creek to the Elbow river, the formations remain very constant in strike, dip and general appearance. The dark shale belt (Claggett and Niobrara-Benton) continues with strike parallel to the mountains to the west, has a very constant width, and maintains a westerly dip of about 35°. Between Cañon creek and the Elbow river a very regular line of low, rounded hills is very noticeable. The Cardium sandstones which form their axes, and hence their summits, have resisted weathering to a much greater extent than the shales on each side. Creeks coming down in an easterly direction from the mountains have worn out valleys and caused the separate hills; otherwise there would be a long ridge for this distance. West of this the Judith River sandstone series dips to the west under the Palæozoic rocks; to the east is a long high ridge running from the west of Coxcomb mountain to the Forgetmenot ridge, and composed chiefly of Dakota rocks, the summit being usually the conglomerate which overlies the coal measures. Cañon creek has cut a wide valley in this ridge, but otherwise it is quite continuous. Thus this outcrop of the coal measures, except along Cañon creek and the Elbow river, is high up on the hills, in fact, near the summit of this ridge. Along the west side of Forgetmenot ridge the conglomerate outcrop forms a ridge higher in most places than the limestones and quartzites.

Up the Elbow.

The mouth of Bragg creek is somewhat to the west of the centre of a belt of Judith River beds about a mile wide. Only the lower members of this series outcrop here, the formation being in the form of a synclinal fold and the upper beds being eroded away, so that the same strata are easily recognized on both sides of the belt. Dark

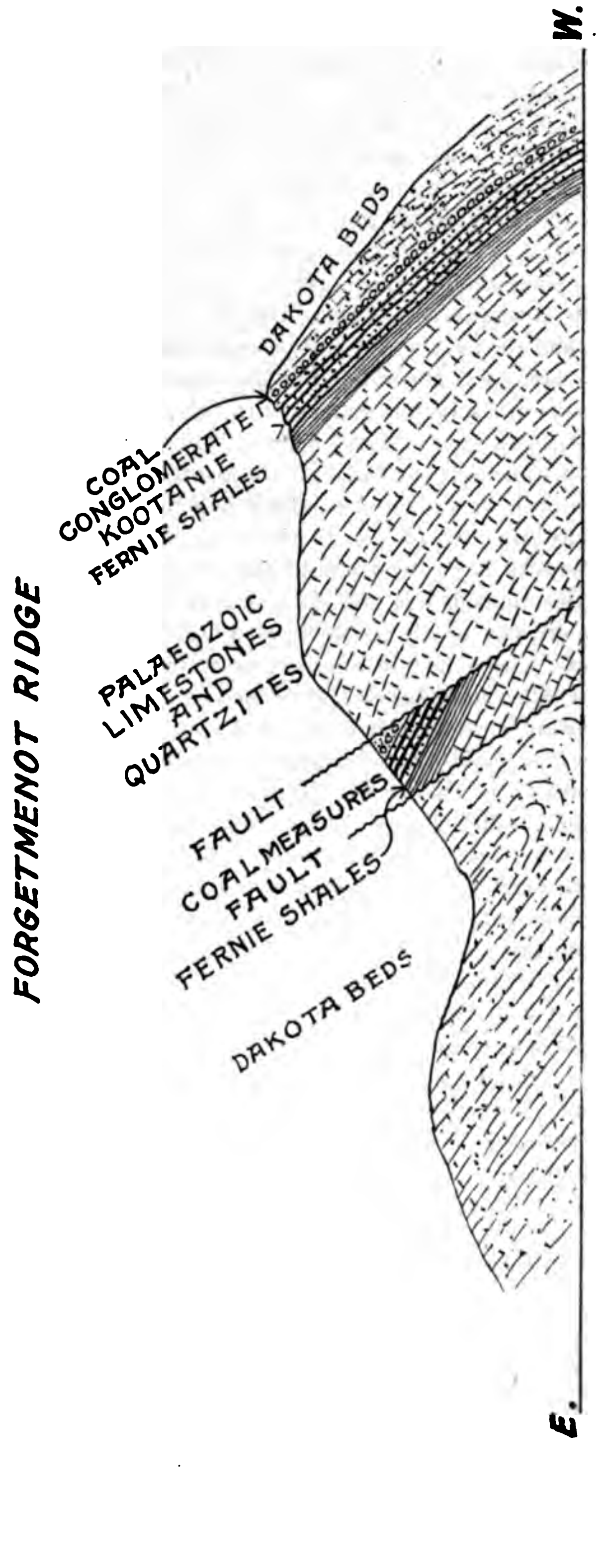
shale series occur on each side, the ones to the west, particularly, being considerably disturbed, folded and broken, causing the Cardium sandstones, intercalated in them, to appear in a number of places. West of this again is the wide low flat syncline of Judith River rocks, which is about three miles wide along the Elbow. This series presents an almost continuous gray appearance and the beds are for the most part soft and coarse-grained, but there are a few, however, which are somewhat harder. The sandstones are chiefly gray and light yellow in colour, the shales being bluish, gray or light yellow.

From the contact as seen along the river, between this last-mentioned series and the dark shales to the west again, it would be difficult to say which series was the older; but the exposures along the hills to the north and south leave no doubts as to this; the contact being well defined and the strata all having regular, low dips to the east for a considerable distance on each side of the contact. This Claggett and Niobrara-Benton belt is about two and a half miles wide here and the dips are chiefly low, 10° to 15°, to the east. However, here as elsewhere, these rocks have been considerably more disturbed than the sandstone series on each side and are repeated by folding and faulting, so that they are not nearly so thick as would be supposed from this wide outcrop. The Cardium sandstones were only noticed in one place, so that when once below the surface the irregularities were not sufficient to bring them up this high again.

West of these shales is a sandstone belt of Dakota about two miles wide. In contrast to the Pierre, Claggett, Benton and Fernie shales, the Edmonton, Judith River, Dakota and Kootanie formations are frequently in this report referred to as sandstone series. This does not mean that they are all sandstones, but merely that they have so much more sandstone that they relatively appear to be sandstone horizons in contrast to the shale formations. The rocks of this Dakota series above mentioned are very different from those of the Judith River, being much harder and on the whole much darker coloured. Here the whole series dips to the east and is somewhat folded, as shown on the section along this river.

Where the Kootanie formation crosses the Elbow at the mouth of Cañon creek the upper parts of the coal measures are exposed and show considerable disturbance. One fairly good regular seam six feet, six inches wide outcrops and others twelve inches and less were seen; the greater part of the measures, however, are under cover. The Fernie shales are well exposed up Cañon creek a short distance from the river, blossoms of iron pyrites being quite plentiful in them, similar to the occurrence at the Thorne mine.

The Kootanie coal measures also outcrop on the west side of this Moose Mountain ridge, all along the western side of Forgetmenot


W.
DAKOTA BEDS
COAL
CONGLOMERATE
KOOTANIE
FERNIE SHALES
PALAEOZOIC
LIMESTONES
AND
QUARTZITES
FAULT
COAL MEASURES
FAULT
FERNIE SHALES
DAKOTA BEDS
E.
FORGETMENOT RIDGE

ridge, and were noticed for a short distance along its eastern side; this is owing to a double fold, the Palæozoic rocks here having been pushed over the Cretaceous and the great pressure causing the Cretaceous also to break and a portion to slide over itself again. The sketch given below shows a section through the Forgetmenot ridge, just south of the Elbow river, where the double faulting occurred.

West of this Forgetmenot ridge, along the Elbow river and the Fisher branch to the mountains, the prevailing dip is to the west. The Dakota rocks dip quite regularly so, but the dark, softer shale series are considerably folded and broken, much more so than farther north, where they are still overlaid by the Judith River beds.

Along the escarpment are the most positive evidences of long periods of erosion over this Cretaceous area before the upheaval of the Rockies to the west. The Judith River beds overlie the Claggett shales from the Bow river to near the Fisher branch of the Elbow, but from here they are entirely eroded away along the river, only one hill about half a mile to the south of the river remaining; to the south of this the Claggett shales are the highest beds seen along the escarpment. Now if this erosion had taken place since the complete up-thrusting of the Palæozoic over the Cretaceous, and hence, since the chief uplifting of the Rockies proper, Judith River beds, or higher ones, would be seen immediately underlying the limestones. However, this is not so, as the same rocks are next the limestone as are seen in the adjoining areas to the east. So this portion of the Foothills was a plain of erosion for long periods before the final uplifts, faults, &c.

The section *A* - *B* shown on the map to accompany this report is approximately along the Elbow river and shows the chief folds, faults, &c., of the different formations across this area in this direction.

South Branch of Fish Creek.

The Judith River beds along the west side of Robinson dip to the east, overlying the dark shales to the west. These shales, Claggett and Niobrara Benton, are in the form of a double fold, and the Cardium sandstones outcrop along the summits of the two north and south ridges north of this branch of Fish creek. In this part of the country outcrops are very scarce, and these hard Cardium sandstones are often the only outcrops to be seen over considerable areas. Even the very summits of some of these ridges are heavily covered with wash dirt and drift. A Judith River belt lies just west of these shales, becoming narrower towards the south and disappearing entirely about three miles south of the creeks. Another belt commences just east and about half a mile north of Bert, and continues to the south branch of Sheep river.

The top of Bert is formed of the Cardium sandstones, the middle sandstone bed forming the summit on which is placed the triangulation station. These sandstone beds here, as elsewhere, are often capped by conglomerate, generally only a few inches to about two feet in thickness, but sometimes considerably more; about one and a half miles southeast of Bert, and just west of the Indian trail, is a nine foot bed of it.

The section through the synclinal, containing Big Meadow and Topknot along this creek (south branch of Fish creek) and the shale belt to the east, is very similar to that along the Elbow river, to the north. The contacts on each side of the Judith River belt here are well exposed, and well defined regular dips were seen on its east and west sides dipping to the west and east respectively,—placing these sandstones decidedly above the Claggett and Niobrara-Benton shales on each side. These shales to the west of this Judith River belt, and north of the creek, are very much the same as to the north; but south of the creek there is a very noticeable change.

Erosion has been greatest down the steep, high sides of the Moose Mountain Palæozoic ridge, which extends south to just about the head of the south branch of Fish creek. The formations outcropping to the south of this ridge, however, are more easily weathered and the hills, which were lower, originally, are much more so now and, on this account, the erosion to the east has been very much less. So great has the effect of this been that the hills to the south of this south branch of Fish creek near its head rise quite abruptly for 1,000 to 1,500 feet from the valley. North of the creek the Judith River formation has been entirely eroded away and only low rolling hills of shales are left, which would be still lower and practically down to base level only for the resistance offered by the harder intercalated Cardium sandstones.

So these causes account for the high ridge to the south of this creek, which is almost continuous from Rock Point to Bert. Rock Point, and the two hills just to the east forming the northern end of Barwell ridge, are in the form of a flat syncline, about two miles wide. The Judith River beds on the tops of these hills can be distinctly seen overlying the dark shales on the north and west sides. Along their west side, along the east side of Long Muskeg, and south to the north branch of Sheep river, the contact is a considerable distance up the hill sides, causing the Judith River formation to appear like a wide flat cake overlying the dark shales.

East of Robinson, to the edge of this map sheet, the outcrops are very scarce. Even the tops of the hills and ridges are often just wash gravel and glacial drift. However, Edmonton sandstones and shales were recognized about two miles east of Robinson, and the Pierre belt was searched for which should lie in between these and the

SELECTED LIST OF REPORTS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE MINES DEPARTMENT OF CANADA

(A.—*Published by the Geological Survey.*)

MINERAL RESOURCES BULLETINS

818. Platinum.
851. Coal.
854. Asbestus.
857. Infusorial Earth.
858. Manganese.
859. Salt.
860. Zinc.
869. Mica.
872. Molybdenum and Tungsten.
877. Graphite.
880. Peat.
881. Phosphates.
882. Copper.
913. Mineral Pigments.
953. Barytes.

745. Altitudes of Canada, by J. White. 1899. (40c.)

BRITISH COLUMBIA.

212. The Rocky Mountains (between latitudes 49° and 51° 30'), by G. M. Dawson. 1885. (25c.).
235. Vancouver Island, by G. M. Dawson. . 1886. (25c.).
236. The Rocky Mountains, Geological Structure, by R. G. McConnell. 1886. (20c.).
263. Cariboo mining district, by A. Bowman. 1887. (25c.).
272. Mineral Wealth, by G. M. Dawson.
294. West Kootenay district, by G. M. Dawson. 1888–89. (35c.).
573. Kamloops district, by G. M. Dawson. 1894. (35c.)
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949. Cascade Coal Field, by D. B. Dowling. (10c.)

YUKON AND MACKENZIE.

260. Yukon district, by G. M. Dawson. 1887. (30c.)
295. Yukon and Mackenzie Basins, by R. G. McConnell. 1889. (25c.)
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. (10c.)
884. Klondike gold fields, by R. G. McConnell. 1901. (25c.)
725. Great Bear Lake and region, by J. M. Bell. 1900. (10c.)
908. Windy Arm, Tagish Lake, by R. G. McConnell. 1906. (10c.)
942. Peel and Wind Rivers, by Chas. Camsell.
943. Upper Stewart River, by J. Keele. } Bound together. (10c.)
979. Klondike gravels, by R. G. McConnell. }

ALBERTA.

237. Central portion, by J. B. Tyrrell. 1886. (25c.)
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-91. (25c.)
703. Yellowhead Pass route, by J. McEvoy. 1898. (15c.)

Benton dark shale outcrops. The top of Mesa Hill is formed of these sandstones, which also outcrop prominently in the shale belt just west of Nigger John.

Light brown, gray, and white sandstones are common in these Judith River belts; also some greenish sandstones and shales appear; a good outcrop of which was seen on Lowndes. On Sinnot 2 brown weathering, light gray and brown sandstones outcrop for some distance. On the east side of Sinnot 1 are the white and light gray sandstones so typical of these Judith River beds. An outcrop of this same formation on Ware creek, about half a mile below Gleason creek, shows a great variety of shales and sandstones. All are light coloured, but all shades of shales from light, bright yellows, to blues and green were seen, as well as light brown, gray, white, and yellow sandstones.

From Nigger John to Death's Head the dips are all to the west and at rather high angles, in most places, but a somewhat abrupt fold has brought the dark shales and Cardium sandstones to the surface just west of Death's Head. The high part of the hill around the station consists of a rather flat layer of very white sandstone overlying the Claggett shales. About a quarter of a mile south of here the formation dips to the south at 28°.

West of Death's Head about two miles is the fault line above referred to. Between it and the dark shales just west of Death's Head the Judith River beds dip to the west in most places, but the formation is very much folded and distorted, much more so than is shown on the section, which, owing to the scale on which it and the other section are necessarily drawn, is in very irregular places, somewhat diagrammatic. West and south of this fault line, i.e.; south of the north branch of Sheep river, south of the Palæozoics of the Forgetmenot ridge and north of Gleasons Meadow and Volcano, is a very irregular block of country. The displacement of the thrust fault east of the Forgetmenot ridge has been quite extensive and to the south of it this fault has given place to a great fold, so that on the top of Allsmoke is the coal conglomerate, overlaid by some of the Kootanie rocks; and on the north side of the hill an almost complete section is shown from the Kootanie down the hill through the Dakota to the Niobrara-Benton and Claggett. So that here these formations are exactly upside down, whereas on Volcano, Gleasons Meadow and Gleason identically the same section appears but right side up. The rocks at Allsmoke have been pushed over each other so as to form a complete double fold and then the top has been eroded off. This is shown in the two sections given through Allsmoke—C.D. being east and west and *E.F.* being north and south. The *C.D.* section also shows the structure approximately along the north branch of Sheep river east of Allsmoke.

This great fold, above mentioned, also accounts for the great variation in the strike of the rocks in this locality. The dips from the north of Volcano and Allsmoke south for several miles are, in a general way, all to the south at low angles, the horizons becoming higher and the hills lower in this direction. Also this displacement of the fault by the fold accounts for the low wide valley north of Allsmoke and west of Long Muskeg, and for the rapid rise of 1,500 feet to 18,000 feet of the hills along the Volcano-Allsmoke ridge from the river on their north side. The rocks of these latter hills have been folded and pushed high up in the air, whereas those of the valley to the north, which are in the form of a low wide anticline, have had the Palæozoics thrust over them.

Quite a wide flat cake of the conglomerate which overlies the Kootanie coal measures forms the top of Gleasons Meadow.

The limestones of Forgetmenot ridge in places appear to be in the form of a complete anticline, especially east of Forgetmenot and Old Forgetmenot, as the western part of the ridge is arched and the arching continues to the eastern edge, which in most places between Threepoint creek and the Elbow river is an abrupt escarpment of from 700 feet to 1,000 feet. This arching causes the dips on the top of the hills to be almost flat, but dipping at low angles to the west, and as the west is approached they become higher until next the Cretaceous they are, in places, 60° to 65°. This shows that here there was considerable folding before the break occurred, which exists all along the eastern edge of this ridge.

South Branch of Sheep River.

For seven or eight miles up the south branch of Sheep river from the mouth of Macabee creek the geology is very similar to that along Ware creek to the north, the noticeable feature being the succession of somewhat wavy, regular folds, causing the Judith River beds and the dark shale series to appear in alternate narrow strips or belts, presenting on the map a ribbon-like appearance. The cause of this folding is the same as to the north along Ware creek, the displacement of the fault east of Forgetmenot ridge is much greater than east of Lower Camp and Gleason and this folding takes up the surplus of lateral area.

The dips from the mouth of Macabee creek to Gorge creek are all to the west, showing that pressure from the west has caused the crests of the folds to be all pushed over. The Cardium sandstones have become much less prominent here than to the north; there being no conglomerates noticed at all, and their thickness west of Lower Camp being only about fifty feet. They still, however, possess the same

characteristics as to the north and the total thickness of the Claggett and Niobrara-Benton has increased to 1,200 feet to 1,300 feet.

The Judith River beds east of Lower Camp contain coal seams in several places as described above, and on account of the accessibility and favourable opportunities for working and prospecting these coals ought to prove of considerable value in the near future. The Judith River belts east of the mouth of Dyson creek are noticeable for their rapid alternations of sandstones and shales, for the general softness of the rocks, and for the great amount of light coloured clay shales, chiefly grey, blue, green, and very light brown. The sandstones, in which are abundant remains of tree-trunks often of large size, are usually coarse and white or gray, being occasionally a very light brown.

In the river banks just above Lower Camp is probably the best section of the Dakota seen this season. It is here all exposed and there is a continuous outcrop from the top to the bottom. The dips are all quite regularly to the west. In the river banks farther up the river, just south and east of Hoffmann, is also a very good section. The description given above of the Dakota formation describes the rocks of these sections quite closely.

The top of the mountain on which are North Greenslope and West Greenslope stations is composed practically of a flat cake of Judith River beds, which can be distinctly seen overlying the dark shale series on all sides, the contact being rather high up on the sides of the mountain. The same thing also exists on the north side of the river in the case of the mountains containing Forks and Missing Links tations. Here, however, the contact is very nearly at the tops of the hills in places.

Just east of Gorge creek is the axis of a wide synclinal fold and from here west for some distance the dips are low and to the east.

The ridge just south of the river and east of North Greenslope is composed of a row of small summits, each one caused by the Cardium sandstones. This is the same thing happening as was seen in the northern part of this district so often, the softer shales weathering rapidly away from each side of these harder sandstones and causing the summits of the hills and ridges.

The wide Dakota area just west of the mountains and south of Threepoint creek and containing Volcano, Ware Head, Hoffmann and Junction is in the form of a high, flat anticline, very similar in structure, and in the rocks composing it to the area north of the Moose mountains. The contact on the eastern edge with the Benton shales is well exposed in the river and in the hills to the south; and the shales are in every case overlying the Dakota beds with low dips to the east. Toward the western side the dips are to the west, and along the river the angle of dip nearly coincides with the angle of

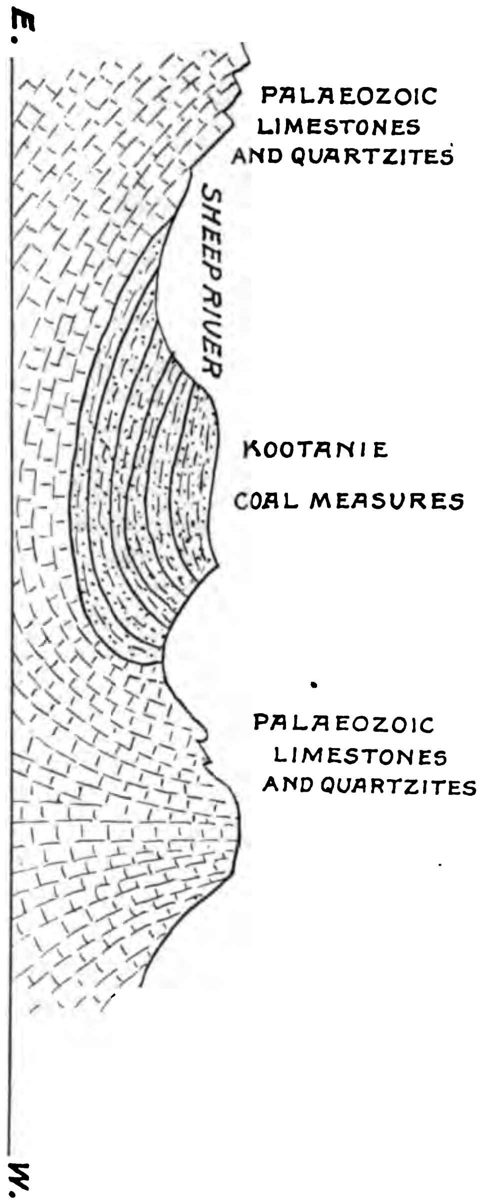
the fault plane between it and the Palæozoic rocks. The central portion of the fold is undulating somewhat, but taken as a whole is practically flat. Ware Head is the axis of an irregular anticlinal fold. The coal measures outcrop in places to the north of Hoffmann, but the outcrops are in most places covered by drift gravels and wash, so that a section of the measures was not obtained here. On the north face of Hoffmann, about half way up it, the conglomerate which overlies the coal measures appears in the form of an arch, the whole hill being a minor anticline somewhat pushed over to the east. The measures are here also mostly covered, but a partial section is to be seen along the river.

P. Burns' Coal Basin.

Just inside the first range of mountains and along the headwaters of the south branch of Sheep river, is a Cretaceous trough carrying valuable coal measures of Kootanie age, of which a considerable area is owned by P. Burns, of Calgary. The coal seams which have been described in another part of this report have been opened up to some extent in a couple of small creeks, running into Sheep river from the west, just about where the Indian trail crosses the divide from the Highwood river.

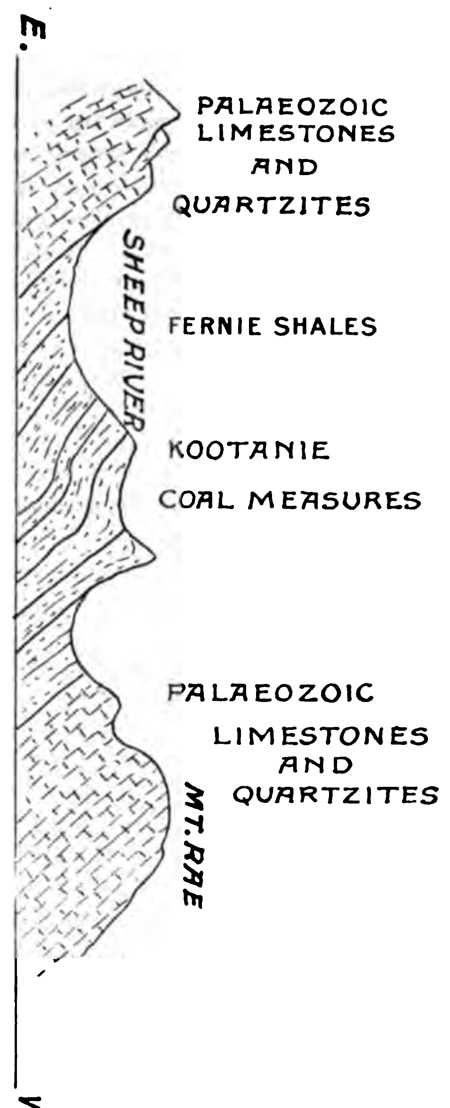
This Cretaceous basin terminates to the north about two and a half miles north of the Elbow river; the southern end was not explored as it extends far to the south of the area covered by this report.

The Cretaceous measures in some places, especially to the south, appear to be faulted along their western edge similar to the following:—



Toward the north, however, a secondary fold is developed as the Elbow river is approached, that causes the trough to become somewhat narrower. Here it appears quite certain that the Palæozoic

rocks to the west have been pushed over themselves and now overlie the Cretaceous. Differences of pressure and in the constituents of the formations allow of the fold being thus altered as below:—



Immediately on top of the limestones are some very hard, fine-grained, almost white quartzites, from 200 to 300 feet thick, and varying in colour from pure white to a light gray. The shales and sandstones which overlie these are much thicker than to the east around the

Moose mountains, although they are otherwise very similar. The conglomerate which overlies the coal measures to the east was not seen here in place, but considerable of the float was found on the hillsides, so that it very probably outcrops on some of the higher points or ridges; but as our work was done late in the autumn, with considerable snow on the ground, we did not find it.

The formation here consists chiefly of sandstones, characteristically brown in appearance. In fact from the river up to the tops of the high rugged Cretaceous ridge here, the whole series is strikingly brown in colour. The sandstones are, for the greater part, quite uniform in texture as well as in colour, being rather fine-grained and not very hard. About half way up the hill a few coarser and grayer beds were seen and also some darker ones. Above this again are a number of black shale beds generally only a few feet in thickness, and often carbonaceous, being at times composed almost wholly of the remains of ferns, &c. Near the top of the hills are a few coarser gray and greenish sandstones. Quite a number of plant remains were collected from this series, all being very characteristic Kootanie types.

The lowest beds of this series were only seen in a few places, but there they correspond very closely with the rocks underlying the coal measures just outside the mountains and even very noticeably have the same peculiar yellowish weathering which so much resembles limestone weathering, although these shales and sandstones in most places contain very little lime.

The high hills of this Cretaceous trough extend in a northwesterly direction along the west side of Sheep river to within about three miles of the Elbow river. From here they rapidly disappear and the Cretaceous and Jurassic instead of being a high rugged ridge become a narrow valley in between the limestone hills on each side. The formation, as it were, goes up in the air; so that about three miles north of the Elbow river it has tapered out entirely. The coal also disappears with the high hills, having been all eroded away in the northern part of the basin.

At the northern end of this trough the same quartzites appear as were seen farther south and they outcrop similarly on both sides, proving that this part of the trough is in the form of a synclinal fold. Along the river the folding of the limestones, also, gives ample evidence of this.

The western contact is high up on the face of the escarpment at the Elbow river, but as the trough is traced northward it descends, and finally, at the point of thinning out entirely, reaches nearly the level of the valley.

Some hundreds of feet of dark shales were seen next the Palæozoic quartzites here, resembling very closely those around the Moose mountains, and they are undoubtedly of the same horizon. Intercalated in

these dark Fernie shales are thin beds of yellowish brown weathering sandstones of medium hardness and texture and reddish-gray in colour. The shales themselves are quite soft and free from coarse sand and often present in their bedding planes quite a soot-like appearance.

FOSSILS.

No vertebrate remains were found.

Specimens of the following invertebrate remains were obtained.

From the Edmonton formation—

Ostrea glabra.

From the Bearpaw shales—

Lingula subspatulata.
Pteria nebrascana.
Baculites compressus.

From the Claggett shales—

Lingula subspatulata.
Pteria nebrascana.
Baculites compressus.

From the Cardium sandstones—

Cardium pauperculum, Stanton.

From the Benton shales—

Inoceramus problematicus.
Scaphites ventricosus.
Mould of an ammonitoid, likely,—
Prionscyclus woolgari.

From the Dakota formation—

Sphærium sp.
Viviparus sp.
Goniobasus sp.
Campeloma sp.

From the Fernie shales—

Guards of *Belemnites* sp.

The above specimens were examined and named by Dr. Whiteaves of this Department.

The plant remains found this season were examined and named by Dr. D. P. Penhallow, of McGill University. The following were obtained:—

From the Edmonton formation—

Sequoia reichenbachi, Heer.
Viburnum, sp.
Platanus newberryana, Heer.

From the Bearpaw shales—
Sequoia reichenbachi, Heer.
Cyadites unjiga, Dn.
From the Judith River formation—
Populus elliptica, Newb.
Betulites, sp.
Dioonites, sp.
Asplenium niobrara, Dn.
Athrotaxopsis tenuicaulis, Font.
Asplenium dicksonianum, Heer.
Thyrsopteris pecopteroides, Font.
Sequoia smittiana, Heer.
Protophyllum haydenii, Lecsq.
Cissites, sp.
Sequoia cuneata, Newb.
Ginkgo baynesiana, Dn.
Palirurus cretaceus, Lecsq.
Salix, sp.
Quercus rhamnoides, Lecsq.
Juglans crassipes, (?) Heer.
Paliurus ovalis, Dn.
Angiopteridium strictinerve. (?)
Ginkgo sibirica, Heer.
Sequoia reichenbachi, Heer.
Sphenopteris johnstrupi, Heer.
Sequoia ambigua, Heer.
Alnites grandifolia, Newb.
From the Claggett shales—
Cycadites unjiga, Dn.
From the Dakota formation—
Carpolithus ternatus, Font.
Fruits, probably of *Ginkgo*.
Sphenolepidium sternbergianum densiflorum, Heer.
Ginkgo lepida, Heer.
Ginkgo sibirica, Heer.
Ginkgo, sp., male inflorescence.
Athrotaxopsis tenuicaulis, Font.
Nilsonia californica, Font.
Ginkgo huttoni, Heer.
Thyrsopteris brevipennris, Font.
From the Kootanie formation—
Dryopteris fredericksburgensis (Font.), Knowlt.
Cycadites longifolius, Font.
Sagenopteris mantelli (Dunk.), Schenk.

Athrotaxopsis tenuicaulis, Font.
Sagenopteris n. sp.
Thyrsopteris meekiana, Font.
Sequoia heterophylla. Vel.
Sequoia smittiana, Heer.
Sagenopteris elliptica, Font.
Baieropsis pluripartita, Font.
Podozamites longifolius, Emmons.
Podozamites lanceolatus (L. and H.), Schimp.
Thyrsopteris insignis, Font.
Thyrsopteris pecopteroides, Font.
Cladophlebis falcata, Font.
Zamites arcticus, Gopp.
Ginkgo huttoni magnifolia, Font.
Cladophlebis constricta, Font.
Nilsonia, n. sp.
Cladophlebis distans, Font. (?)

Some of the types found in the Judith River formation have by some authorities been considered as belonging to the Dakota.

GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DEPUTY HEAD AND DIRECTOR. 1·07

REPORT

ON THE

GEOLOGY AND NATURAL RESOURCES

OF THE AREA INCLUDED IN THE

NORTHWEST QUARTER-SHEET, NUMBER 122

OF THE

ONTARIO AND QUEBEC SERIES

COMPRISING PORTIONS OF THE

COUNTIES OF PONTIAC, CARLETON AND RENFREW

BY

R. W. ELLS

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1907

No. 977

John Quirk's Ranch. This is the most westerly ranch up the north branch of the Sheep river.

Contact between Foothills and Rockies proper, as seen from the Elbow river.

CONTENTS.

REPORT

ON THE

GEOLOGY AND NATURAL RESOURCES

OF THE AREA INCLUDED IN THE

NORTHWEST QUARTER-SHEET, No. 122, OF THE ONTARIO AND QUEBEC SERIES

COMPRISING PORTIONS OF THE COUNTY OF PONTIAC, QUEBEC, AND OF CARLETON AND RENFREW COUNTIES, ONTARIO,

BY R. W. ELLS.

INTRODUCTION.

The official number of the map-sheet to which this report relates is No. 122, known as the "Pembroke sheet." It lies west of and joins map-sheet No. 121, or the "Grenville sheet," and has an area of 3,456 square miles. The eastern limit of the sheet is not far from the Gatineau river, north from Ottawa city, and the southwestern portion is traversed by the Ottawa river from a point about thirty miles west of Pembroke to within ten miles of the city of Hull.

POSITION OF STREAMS.

The area north of the Ottawa is intersected by several large streams. In addition to the Gatineau, which crosses near the eastern margin of the map, from the northern limit of the townships of Northfield and Wright, there are several large branches of this stream from the west. The principal of these is the Pickanock which rises in large lakes, among which Dumont and Squaw lakes, in the unsurveyed area north of the townships of Huddersfield and Clapham, are the most important. The stream joins the Gatineau in the central part of Wright township nearly sixty miles north of the city of Ottawa. Farther south other important tributaries are the Kazabazua, Stag creek and the Pêche river, the last entering the Gatineau near the village of Wakefield.

In the western portion of the area included in the map are the Coulonge and Black rivers, both large streams from the north. The former enters the Ottawa at the village of Fort Coulonge in the township of Mansfield, about three miles above the head of Calumet island, while the latter flows into the north or Culbute channel of the Ottawa, near the lower end of Allumette island, in the township of Waltham, about nine miles west of the mouth of the Coulonge.

The area on the south side of the Ottawa is also intersected by several important streams. Of these one of the largest is the Petawawa which rises near the headwaters of the Muskoka river and flows northeast until it meets the Ottawa about nine miles west of the town of Pembroke. For a large part of its course this river has the reputation of being rough and difficult to traverse with canoes. It was, however, surveyed in 1853 by Mr. Alexander Murray of the Geological Survey, who reports that the country thus traversed is largely granitic in character throughout the greater part of its course.

Among other streams which flow into the Ottawa from the south, and are included in the area of the map-sheet, are the Indian and the Musquash rivers, which come in at the town of Pembroke, and the Bonnechére, a large river which joins the Ottawa at a point on Chats lake about twelve miles west of the town of Arnprior. The Madawaska, also an important stream which enters the Ottawa at the latter place, lies to the south of the present map-sheet.

The area north of the Ottawa, with the exception of a belt of townships in the more immediate vicinity of the Gatineau and those adjacent to the Ottawa itself east of the Black river, is almost entirely unopened for settlement. West of the Black River roads extend along the north side of the Ottawa to the deep bay at the lower end of what is known as the Deep river opposite High View, which is at the sharp bend about twenty miles above the town of Pembroke. Roads also extend north nearly to the rear of the township of Sheen, but a large portion of this area is still unopened. Between the Black and Coulonge rivers several settlement roads have been made for a distance of eight to ten miles, and portage roads continue along these streams for some miles farther. In all these townships the travelled roads are in close proximity to the Ottawa. Beyond these the country is generally rough and practically inaccessible outside of the canoe routes along the rivers mentioned.

East of the Coulonge the country is fairly well opened up as far north as the head of Otter lake on the Pickanock river whence a

umber or portage road extends northwest to Squaw lake and thence to the upper part of the Coulonge river.

South of the Ottawa the area between the river and the Bonnechére is much less broken, and good settlements are common. There are here large outcrops of the limestones of the several Palaeozoic formations, the decay of which usually produces a soil very favourable to agriculture, and the crystalline limestones also have a comparatively widespread development as compared with the country north of the Ottawa.

This portion of the map-sheet is also traversed by several lines of railway, among which are the Canadian Pacific from Ottawa westward, the Grand Trunk, and the Pembroke Southern which extends from the town of Pembroke to meet the Grand Trunk at Golden lake. On the north side of the Ottawa the only railway yet constructed, in addition to the line up the Gatineau river, is the Waltham branch of the C. P. R. system, which now terminates near the mouth of the Black river. The Maniwaki branch of the C.P.R. system extends northward, keeping for a considerable part of its course in close proximity to the Gatineau river. This road for some years ended at the village of Gracefield, about one mile above the mouth of the Pickanock, but is now completed to Maniwaki, at the mouth of the Desert river.

The area included in map-sheet No. 122 presents somewhat different geological features from those found in the adjoining map-sheet to the east. In the part near the Gatineau river there is a much greater development of the crystalline limestones belonging to the Grenville or Hastings series than in the western half of the area. This area of calcareous roc's, while greatly interrupted by masses of granite and occasional outcrops of the grey gneiss, has a breadth from east to west of nearly fifteen miles, and extends northward far beyond the limit of the map-sheet. Its distribution in this direction along the Gatineau river and its tributaries has already been briefly described in the report on map-sheet No. 121.

Westward of the calcareous rocks, the formation is largely granitic in character. These granites are often well foliated, though this feature is also frequently absent. Along the Coulonge river as far north as our examinations along this stream extended, or to a point about seventy miles from its junction with the Ottawa, measured along the stream, large areas of greyish and reddish-grey gneiss are seen. They are

associated with beds of crystalline limestone and quartzite, resembling in this respect the characteristic rocks of the Grenville series. Large portions of this district are covered by heavy beds of sand. The limestone and quartzite are rarely seen west of the mouth of the Black river.

South of the Ottawa large outcrops or outliers of Palaeozoic rocks, principally Black River limestone, occur, while the western part of this area, especially in the townships of Alice, Fraser, Petawawa and Buchanan, is occupied to a large extent by heavy deposits of clay and sand.

In connexion with the crystalline limestone and associated gneiss found in the district south of the Ottawa there are large areas of crystalline schist. Rusty and yellowish weathering dolomite, often with irregular bunches of quartz, is also a marked feature in the rocks of this district. The schists and dolomite have a wide development along the line of the Kingston and Pembroke railway, being the northern prolongation of large masses of these rocks which are found in the counties of Frontenac and Hastings.

The earliest work on the geology of the district dates back to 1852-53, and was done by Mr. Alexander Murray, the then Assistant Director of the Geological Survey. In the latter year Mr. Murray made a number of traverses and surveys of important rivers in the country south of the Ottawa, comprising the Petawawa from its source near the headwaters of the Madawaska and Muskoka to the junction with the Ottawa above Pembroke; and the Bonnechére from the Ottawa to Round lake which is a few miles west of Golden lake on the Grand Trunk railway. From Round lake a traverse was made across country to the Madawaska River waters, which were reached at what is now known as Barry bay. The geological features of the country adjacent to these rivers were carefully mapped at that time.

In 1853 Mr. James Richardson made a series of surveys in the Pembroke district, including Allumette island, and continued his work east by pacing the road from Pembroke to Ottawa city. Later, in 1876, Mr. L. R. Ord, working with Mr. H. G. Vennor, carried on the work in this area, surveying the greater part of the roads to the north of the Ottawa between Coulonge river and the Gatineau, and on the south side over portions of Westmeath, Ross and Horton townships.

In his report for 1876 Mr. Vennor describes the leading geological features along the Ottawa from the town of Arnprior as far west as the junction with the Mattawa river. The distribution of the crystalline limestone in the eastern portion of the county of Renfrew is also given, and the connexion of these with similar limestones north of the Ottawa is clearly stated, the two being regarded as equivalent formations. In this way the rocks which had been described in the earlier reports under the name of the "Grenville series" were shown to belong the same horizon as those which in the area south of the Ottawa had been styled by Vennor the "Hastings series." The statement thus put forward by Vennor, nearly thirty years ago, has been to a large extent supported by the detailed work in the district, as well as to the east and west, during the last ten years. A large amount of attention was also given by Mr. Vennor to the study of the economic minerals of the area, more especially to the deposits of iron, mica, graphite and apatite.

The relations of the several divisions of the crystalline rocks in eastern Ontario will be found discussed fully in the preceding report on the Perth sheet.

The different rock formations found in the area comprised in map-sheet No. 122 are as follows :—

Palaeozoic formations.

Trenton limestone.
Black River limestone.
Chazy limestone and shales.
Calciferous dolomite.
Potsdam sandstone.

Crystalline rocks, including :—

Granite and granite-gneiss.
Gneiss, quartzite and limestone of the Grenville series.
Anorthosite and other igneous rocks.
Post-Pliocene deposits.

Owing to the fact that the crystalline rocks are the more important geological feature in the area under consideration, their description will be first given.

THE CRYSTALLINE ROCKS.

In general character the crystalline rocks of the area north of the Ottawa and west of the Gatineau river closely resemble those already

Preliminary report on the Limestones and the Lime Industry of Manitoba. J. W. Wells. 1905.

Preliminary report on the raw materials, manufacture and uses of Hydraulic Cements in Manitoba. J. W. Wells. 1905.

Preliminary report on the industrial value of the Clays and Shales of Manitoba. (Only a few copies available.) J. W. Wells. 1905.

Mica, its occurrence, exploitation and uses. Fritz Cirkel. 1905. (Only a few copies available.)

Asbestus, its occurrence, exploitation and uses. Fritz Cirkel. 1905.

Report of the Commission appointed to investigate the Zinc Resources of British Columbia and the conditions affecting their exploitation. W. R. Ingalls. 1905.

Report on the present and prospective output of the Mines of the Silver-Cobalt ores of the Cobalt District. Eugene Haanel. 1907.

Report on the Mining Conditions of The Klondike, Yukon. Eugene Haanel. 1902.

IN PRESS.

Monograph on Graphite. Fritz Cirkel.

the Green Lake portage route, by which a rough portion of the river is passed. The general strike of the rocks here is to the northwest, following generally the course of the stream. The upper portion of the Black river is occupied, as far as our traverse extended, by the granitic portion of the series.

Along the Coulonge the gneiss of the Grenville series is associated with quartzite and limestone. The gneiss is sometimes very well bedded, and in the cliffs on some of the lakes, notably on Bryson lake, the outcrops closely resemble well-bedded masses of Potsdam sandstone. In this respect the rocks are very similar to certain of the gneisses seen on the upper part of the North Nation river in the Grenville district.

Along the north side of the Deep river (Ottawa), certain portions of the gneiss formation are well banded and the dip is at a high angle, sometimes to the east, but in places to the west, indicating an anticlinal structure. The same features are seen in the rocks where exposed along the south side of the river, though the exposures are here less frequently seen owing to sand deposits which prevail over much of the area in this direction. In places, however, especially towards the Rapides des Joachims, the rocks are more massive.

In the area between the limestones of the Gatineau River belt and the outcrops of the similar rocks along the Coulonge river there appears to be a marked divergence in the strike of the gneiss, which extends for a considerable distance. Thus in the former district the strike of the gneiss and associated limestone varies from N. 50° E. to N. 10° E., while along the latter stream the general strike is from twenty to thirty degrees west of north. The cause of this divergence seems to be the presence of a large area of granite and granite-gneiss which is extensively developed in the country east of the Coulonge and which extends across to the upper part of the Pickanock waters. The peculiar action of certain portions of this mass is seen in the abrupt termination of some of the limestone bands as well as the associated gneiss at a number of points. This divergence in the strike of the gneiss and limestone through the agency of granite masses is also well seen at other points in the area of the Grenville sheet, as also in that to the south.

COULONGE RIVER.

The Coulonge river has a length of about 150 miles. It enters the Ottawa near the village of Fort Coulonge, in the township of Mansfield, about three miles west of the head of Calumet island. The current is

often swift and in many places broken by heavy rapids and falls which render its ascent difficult for canoes. The upward journey is generally accomplished by taking advantage of a chain of lakes along the west side which extend north for about thirty miles, or, by making several portages and continuing the route through Bryson lake and creek, the main stream can be reached at about seventy-two miles from the mouth, or one and a half miles north of the junction of Crow river, a tributary from the east. Above this point on the Coulonge the ascent of the river is much more easily accomplished.

Along that part of the stream for half a mile on either side of the Crow river grey gneiss, associated with bands of crystalline limestone, is the prevailing rock. The gneiss is sometimes rusty and in places associated with black bands, probably an amphibolite, having a strike of N. 20° W. and dipping N. 70° E. 15°-20°. The limestones appear at several points below, notably at the small bend about two miles above the first fall, which is between the sixty-four and sixty-five mile posts.

This fall is about seven feet high, over dark hornblendic, with reddish and grey, gneiss, the strike and dip of which are the same as just recorded, and this appears to be the general strike of all the rocks throughout this part of the country. The portage past the fall is a fourth of a mile in length, on the west bank of the river, and the gneiss and limestone are here abruptly cut off by a mass of red granite. A conglomerate band is seen in the limestone a short distance above the falls, the pebbles consisting of red and grey gneiss, well rounded and stuck in the limestone at all angles. The resemblance of these pebbles to the rocks of the Grenville series, as also to those of the Hastings series as seen along the Mississippi river, is very marked.

At this fall a steep granite mountain rises to the west of the stream, but below this as far as Devil chute, almost twelve miles farther down the river, the shores are generally low and for the most part consist of sand and gravel. Occasional outcrops of the usual gneiss appear with a dip of N. 80° E. $<$ 60°-80°. The same dip is seen at the Chute in greyish and black gneiss which is cut by granite dikes. Small bands of limestone with inclusions of rusty gneiss are found at many of the gneiss outcrops. In places the limestone is quite dolomitic and weathers a buff-yellow. High ridges of granite-gneiss occur along the east bank of the river, between the main stream of the Coulonge and the east branch.

Below this for some miles the course of the river is much more crooked. The exposed rocks are usually of the gneissic variety, for

the most part of a reddish colour, but with associated black and grey bands, and occasionally a band of buff-weathering dolomite is seen. At what is known as the Post-office rapid, a short distance below the forty-eight mile post, the dip changes to southwest $< 20°$, and on a trail thence to Murtagh depot, which is about one mile and a half east of this place, a ridge of the granite gneiss is crossed. The country in this direction appears to be much more broken, and high ridges are numerous. Small patches of a pinkish limestone, generally much contorted, are found with the granitic rocks of this part of the river.

Thence down stream the shores are lower, with sandy or gravelly banks and occasional ridges of high land. At Duval creek, near the forty-four and a half mile post, there are high hills on the southwest of a coarse reddish granite, but a short distance above this point the usual reddish-grey and black gneiss dips N. 70° E. $< 40°$.

From this place to Ragged chute, which is at the thirty-six mile post, the shores are sandy and no ledges are seen, though hills rise a short distance back from the stream. This chute is over a mass of red granite which is intruded through the gneiss, and the place is very rough, with bold cliffs of red granite and gneiss on the east bank and low ledges of the same on the west side. No foliation could be determined in the rocks at this place. The falls are ten or twelve feet in height and the portage comes down over a wing dam and along an island in the stream. The granite forms heavy rapids in the river below, and there is a dike of diabase six inches wide which cuts the granite and gneiss.

At Gelinas chute, which is at the thirty-four mile mark, the gneiss is much broken up by intrusives, but a little below this place it assumes a strike of N. 30° E. and dips S. 60° E $< 10°$.

Below this again to the forks of the East branch the shores are low and gravelly, and no ledges show along the stream. The ascent of the East branch was not practicable at the time of our visit, owing to the low stage of the water. It is described as a very rough stream with many falls and portages, and the rocks are probably largely of the granitic or granite-gneiss varieties.

Below the Forks the shores for several miles are largely composed of sand and gravel. Occasional ledges of grey and black gneiss are seen, and at the Poplar rapids these gneisses contain a small band of yellow-weathering dolomite. The strike here is N. 30° E. and the dip S. 60° E. $< 10°$. At the Bear chute, near the twenty-six mile mark, the

strike of the grey and black gneiss is N. 20° W. and the dip N. 70 E. < 20°. Below this for several miles similar rocks are seen at intervals.

The river from the twenty-six to twenty-three mile marks is very rough, making navigation with canoes treacherous. Steep mountains rise on both sides and there are several portages.

The Island rapids are caused by heavy masses of coarse granite which cut the gneiss, and along the portion of the stream between the twenty-five and twenty-three miles posts, large blocks of green pyroxene are seen along the shore.

Between this and Bryson creek, which comes in from the west near the seventeen mile mark, are several rapids, the current being very strong and in places rough. Among the rapids are the Island, Horseshoe, Trois Roches and Long. The rocks along this stretch of the river are mostly reddish-grey and grey gneiss with small bands of limestone, all of which are cut by masses of red granite. Similar gneiss and limestone bands continue down to the Grand falls, which are about four miles above the village of Fort Coulonge, but in the last four miles before reaching the falls the shores are low and composed of sand and gravel, rock outcrops being very rarely seen.

The Grand falls are sixty feet in height, over masses of limestone and granite, but below this to the junction with the Ottawa the river flows through sand plains, underlaid by clay of the usual bluish-grey variety.

BLACK RIVER.

The Black river was ascended for about seventy miles, whence a route was followed across to the Coulonge by way of Foran creek and lake, and Lynch, Travers and Bryson lakes and the upper Bryson creek. None of these lakes except the last are indicated on any map in our possession, and in the absence of any guide who knew the proper portages some difficulty was at first encountered in finding our way across. The portages are usually short and easy, except the last to Bryson lake which is two miles long over a rather steep ridge.

The country along the lower ten or twelve miles of the Black river, between this stream and the Coulonge, is traversed by several roads, which meet at what is known as the Culbute, a fall and rapid about ten and a half miles from the mouth of the river, which joins the back or Culbute channel of the Ottawa near the lower end of Allumette island.

Small ledges of gneiss also show at forty-four miles, and there is a large cliff of red granite on the west side above the forty-five mile mark.

Above this for a couple of miles granite and gneiss hills rise on the east of the stream. At fifty miles there is a rapid, the water flowing over rusty quartzose gneiss which has a southwest dip < 10°, and at the Bear rapid, one mile above, banded gneiss is cut by granite dikes, the dip of the former being west < 15°. The banks of the river all along are composed largely of sand.

About one mile above Bear rapids is the foot of the Mountain portage. This is three miles in length, past a very rough portion of the river with a heavy chute at the upper end. The rocks are all gneiss and granite with a dip to the west < 20°-30°. Thence up to the fifty-eight mile post the river is broken by chutes and heavy rapids, and the ascent is difficult; the rocks are exposed at frequent intervals and consist of gneiss with some granite throughout. Greyish mica-gneiss, cut by granite, is seen at sixty-two miles with a dip to the S.W. < 12°, and thence up to Foran creek, where the portage route to the Coulonge takes off to the east; the banks are for the most part of sand, and the country is low or broken by scattered ridges of gneiss and granite.

The upper part of the Black river was not examined. It apparently flows for a good part of its course through sandy country, and the Crown Lands survey of the stream shows no falls and but few rapids.

No limestone was seen along the route traversed between the Black and Coulonge rivers, though bands of this rock may occur along the shores of some of these lakes. The rocks observed were all gneisses of the Grenville series, well-banded and showing the presence of several anticlines between the two rivers.

Along the shores of Bryson lake the principal rock outcrops are of greyish quartzose and sometimes black gneiss, generally well-banded. This lake is twelve to fourteen miles in length from south to north, with several long bays and numerous islands scattered throughout. It discharges by a creek about three miles in length from a bay at the northeast end, into the Coulonge river, as already noted in the remarks on that stream.

OTTAWA RIVER.

The Ottawa river, which traverses the area of the map-sheet diagonally across the southern half, presents some interesting features

both from the physical and geological standpoint. The valley of the river is of great antiquity, and was undoubtedly excavated before the time of the Potsdam sandstone, since this, the oldest of the Palaeozoic formations in the district, was deposited upon the eroded Archæan floor.

The present channel of the river presents a series of somewhat narrow lake expansions which extend from the city of Ottawa to the Des Joachim rapids, a distance of about 150 miles along the stream. The first of these in ascending order is Lake Deschenes which extends from Britannia to the foot of the Chats falls. The elevation of this lake or expansion of the Ottawa, taking the low water readings for Mr. J. White's book on "Altitudes in Canada", is 189 feet above the sea. This part of the river is navigable for steamers throughout its entire length to Fitzroy harbour which is just below the falls.

The waters of this river expansion are separated from those of the next above, which is known as the Chats lake, by the Chats falls and rapids. The elevation in the river caused by this obstruction to navigation is about fifty feet. Chats lake with an elevation of 239 feet (low water level) extends to the Chenaux rapid, where the ascent is broken by a slight fall of only a few inches at low water. This can be readily ascended by steamers, and the navigation is thus continuous from the foot of Chats lake a short distance below Arnprior to Portage du Fort village.

At this place the upward navigation is broken for some miles by a series of heavy rapids and falls. The river is divided into two channels, a short distance above this village, which flow on either side of Calumet island. That on the south side is known as the Roche Fendu channel, and that on the north as the Calumet channel. The former is very rough for the greater part of its course, there being a total rise of 100 feet from the foot of the Portage du Fort rapids to the head of La Passe rapid, a distance of twenty-six and a half miles.

On the Calumet channel the broken water space is much shorter, terminating at the village of Bryson where steamboat navigation is again resumed. This place is about eight miles north of Portage du Fort by road, the rise in the river in this interval being about ninety-six feet. The Calumet channel, which flows past the north side of the island, is largely cut out of sands, so that the navigable channel is liable to change every year during the period of high water in the spring.

The elevation of Lake Coulonge, which is the usual name of the lake expansion between the head of Calumet island and the foot of Allumette island, which is about eleven miles farther west, is placed at 341½ feet above sea-level, and of the channel at the foot of Allumette island as 344.2 feet.

The two channels which flow past this island are known as the Culbute on the north side, and the Pembroke around the south and east sides. The former is quite straight and is broken by two rapids and a fall. The first rapid is at the village of Chapeau and is about a foot in height, but the l'Islet rapid and Culbute fall, which are now overcome by means of a lock, have a rise of seventeen feet and the elevation of Pembroke or Allumette lake is given as 363.5 feet above the sea.

The south or Pembroke channel is broken by two rapids, the lower known as Paquette near the lower end of the island, and the upper or Allumette rapid about three miles below the town of Pembroke. Steamboats run from the village of Bryson to the foot of Paquette rapids, and formerly by passing the lock in the north channel could enter the Allumette lake and thus continue to the foot of des Joachims rapid, at the head of what is known as the Deep river or the portion of the Ottawa lying between High View and the rapids just mentioned. The altitude of the Deep river is given as 364.8 feet.

The course of the Ottawa, being for the greater part almost at right angles to the strike of the rocks throughout this area, affords a very fair section across the southern portion of the map-sheet. Along the part between Ottawa city and the Chats falls the Palaeozoic formations including the Potsdam, Calciferous and Chazy are well exposed, especially along the south or Ontario side. On the north side the Chazy and Calciferous extend westward as far as the mouth of Breckenridge creek when the granite and gneiss come to the shore and continue up river to within about one mile of Quio village. Here dolomites of Calciferous age again appear resting on the eroded surfaces of the granitic rocks and capped by the greenish-grey shales and sandstones of Chazy age in the village itself. To the north, on the bank of the Quio river in rear of the village, Potsdam sandstone occurs, and it is possible that a fault crosses this area by which the extent of the Calciferous is much reduced. The dolomites are again seen at the foot of the Chats falls on the north side of the river at the village of Old Pontiac in a very limited outcrop, but the Potsdam sandstone does not occur at this place.

Passing the Chats falls and rapids, which are caused by a barrier of crystalline limestone much intersected by granite dikes, outcrops of gneiss, schists of various kinds, diorites and red granite again appear along the north shore. At the road leading down to the ferry which crosses to Braeside from Bristol iron mines the Calciferous dolomite occurs in irregular patches upon the crystalline rocks and forms a narrow margin along the shore as far west as the point near Norway bay, above which another point below Bristol wharf is formed of granite and gneiss with some limestone. The crystalline limestone is seen at frequent intervals as far west as Portage du Fort village, interstratified in places with bands of greyish gneiss, and occasional masses of granite and anorthosite. Large portions along the north side are occupied by heavy deposits of reddish sands; which are extensively developed in the townships of Bristol and Clarendon, situated to the north of this part of the Ottawa; and occasional masses of red granite are seen, with small bands of crystalline limestone. In the northern portion of Clarendon township there is a large area of granite, in places without foliation, which rises to the east of the Ottawa a short distance below the village of Bryson, and extends northerly into the townships of Thorne and Leslie. The breadth of this large mass is about ten miles from east to west.

Along that part of the Ottawa between Portage du Fort and Bryson the rocks are for the most part calcareous. The limestone in places forms a marble of excellent quality, which has been quarried, and some of the decorative pillars for the Parliament buildings in Ottawa were taken from the rock near the former village. A new quarry has been opened within the last half-dozen years near the Bryson road, about one mile and a half north of the Portage village. Small patches of Calciferous dolomite also occur along this road which turns off to the eastward about two miles north of the village, the rock resting upon the eroded surface of the crystalline limestone.

CALUMET ISLAND.

The part of the Ottawa river between this village and Bryson is very rough and broken by numerous heavy rapids and falls. These are caused by dikes and masses of granite which have broken through the limestone and twisted the latter in every direction. Masses of green stone or diorite also occur, and in places the rock is serpentinized and small veins of chrysotile occur. This feature is well seen at the Grand Calumet falls about half a mile below Bryson village, and also in a cliff of limestone at the west end of the bridge over the Ottawa leading across to Calumet island.

The east end of this island is occupied largely by granite and diorite. Along that portion bordering on the Ottawa river and extending from the shores of the Roche Fendu lake to Bryson an irregular band of crystalline limestone occurs which is much broken across and injected with granite dikes, some of which are of large size. The granite mass extends across the Roche Fendu channel into Westmeath township, and westward on the island to about the line between lot one, range VII, and lot 22, range III, where ledges of limestone and grey gneiss again appear. The eastern end of the island, in addition to the granite, also shows large masses of diorite or gneiss in which large pockety masses of galena and zinc blende occur, which have been worked at irregular intervals for some years. The west half of the island consists in large part of plains of sand, with a small growth of pine, and the rocks where exposed are greyish gneiss with occasional thin bands of limestone. On the southwestern extremity greenish Chazy shales occur, underlaid by the Calciferous dolomite. This is in the area opposite the point known as La Passe on the Ontario side of the river. The dolomite and overlying shales rest upon the gneiss and granite of the west end of the island. They form the lowest beds of the Palaeozoic basin in this direction, the rocks of which occupy nearly the entire surface of Allumette island to the west, as well as large portions of the townships of Pembroke, Stafford and Westmeath on the south side of the Ottawa.

The channel around the north side of Calumet island is cut through sand for the greater part of the distance from La Passe to Bryson. Hills of granite rise on the south side of the channel opposite Campbell bay, while along the north side of the river in the township of Litchfield similar granitic rocks are a conspicuous feature. These granites are generally foliated, and in places there are areas of the Grenville gneiss and limestone. This granite-gneiss belt extends across to the headwaters of the Pickanock and is well displayed to the west of Otter lake in the townships of Huddersfield and Clapham, and around the shores of Lake Dumont still farther north.

Between the head of Calumet and the foot of Allumette islands the shores are generally low and are composed largely of sand and clay. Above the mouth of the Coulonge river, at Pointe Seche, on the north side of the Ottawa, flat-lying ledges of Black River limestone are exposed, from which the characteristic fossils of this formation have been obtained. Crossing a rather deep bay on the north side of the river, above this point, ledges of Trenton limestone appear on the west

side underlaid by limestones of Black River age. These in turn rest upon the eastern flank of a hill of gneiss and limestone, much broken up and intersected by masses of red granite.

The lowest beds of the Black River formation at this place are dolomitic and were at first supposed to belong to the Calciferous formation but the finding of masses of *Columnaria halli* and of *Tetradium fibratum*, with other characteristic forms, has enabled us to determine their exact position. The basal beds are inclined against the crystalline rocks at an angle of nearly fifty degrees and are somewhat altered. The locality is a few hundred yards east of the place called The Boom.

Thence up the river to the foot of Allumette island the banks are generally low and sandy and ledges are not seen. Along the south shore, however, pieces of the Black River limestone are common, and there are low ridges largely made up of these rocks, so that it is probable that the formation extends in this direction over a considerable part of Westmeath township. On the north side of the Ottawa, gneiss and granite, with occasional thin bands of crystalline limestone, are seen a short distance inland, protruding through the sand drift, where they form the southern edge of the great Archaean mass.

At Paquette rapids, which is at the lower part of the Pembroke channel near the lower end of Allumette island, large ledges of Black River limestone cross the stream. These abound in well-preserved fossils of which large and characteristic collections have been made by several officers of the Geological Survey. The Black River formation would appear to occupy a considerable part of the eastern half of this island, overlying the Chazy limestones which are well exposed along the shore near the Allumette rapids, about three miles below the town of Pembroke, and which there rest upon greenish-grey sandy shales which represent the lower portion of the Chazy formation. These shales are also well developed on the south side of the river in the vicinity of and to the rear of the town of Pembroke. They also occupy several of the large islands in the channel from three to four miles below this place.

ALLUMETTE ISLAND.

Allumette island, while largely occupied by sands and clay, especially along the north side and east end, shows at several places outcrops of the Palaeozoic rocks. On the extreme northwest corner above the Culbute lock ledges of granite-gneiss are exposed along the shore, as also at the bridge near the village of Chapeau. These old rocks resemble

the fundamental gneiss of the Laurentian. They are overlaid near the northwest corner of the island by Calciferous dolomite, which occupies the west end and extends along the shore southward for about three miles in the direction of Pembroke, where it is in turn overlaid by the Chazy shales. The dolomite has a low dip of three degrees to the south, and similar rocks occur on the south side of the Ottawa at intervals nearly to the west line of Pembroke township, forming a narrow margin along the shore. The Potsdam sandstone was not seen in this direction.

The Chazy shales which overlie the Calciferous continue along the south side of the island for some miles, and are occasionally exposed along the beach, the beds being nearly horizontal. They pass up into the Chazy limestone near the head of Allumette rapids, the latter being well seen in a quarry on the island near the foot. The exact limit of the several formations is hard to determine owing to the paucity of exposures, much of the interior part of the island being sand covered.

OTTAWA RIVER—*Continued.*

The sands continue westward along the course of the Ottawa river past the village of Fort William, and extend northward over the southern part of the townships of Waltham, Chichester and Sheen, until they meet the bold ridge of crystalline rocks which formed the ancient limit of the river channel in pre-glacial times. Over this intervening space the sands and gravels frequently occur in ridges, and rock outcrops are rarely seen. Above Fort William the course of the river changes to an almost north and south direction for several miles to the foot of the stretch known as the Deep river, which name is given to the Ottawa for that portion between High View and the Rapide des Joachims, a distance of nearly thirty miles, the water in portions of this stretch being reported as quite 500 feet in depth.

The rocks along that portion of the river from the Culbute falls and lock in the north channel, to MacKay point opposite High View or the lower end of the Deep river, where exposed are all granite gneiss. Banding is rarely seen, and even foliation is frequently absent, the rock having the aspect of a massive granite.

In the area north of the Deep river the first prominent feature is what is know as Oiseau rock. This is a bold headland of reddish-grey gneiss and granite, in places well foliated, rising to a height of 500 and in places probably 800 feet above the river. A short distance above the rock the foliation has a strike of N. 15° E. the dip being to the east 30°. The rocks, however, lack the banded aspect of the gneisses of the Grenville series

The granitic rocks extend in a bold ridge to the Narrows, about seven miles farther west, where they form bold cliffs. At this place there is a band of dark dioritic rock, about fifty feet wide, containing pebble-like masses of similar looking rock.

Above this to the mouth of the Shehyn river the shores become gradually lower with intervals of sand, but ridges of granite-gneiss rise a short distance inland. The rock has the same generally reddish colour and is in places foliated. To the north along the whole stretch of the Deep river the country is reported as very rough with great hills and abrupt cliffs, and almost impassable except in winter.

At the entrance to the shallow bay, about one mile east of Shehyn river, a thin irregular band of crystalline limestone, with a little grey gneiss, occurs along with the granite-gneiss. This limestone is much twisted and appears as if caught in a mass of intrusive granite and crushed out of its regular stratified character.

While the dip of the foliated gneiss at the Oiseau rock is to the east, above the Narrows it inclines to the northwest, indicating an anticline, and occasionally the strata appear to be nearly horizontal. In most cases, however, the banding as well as the foliation are perceived with difficulty, and the rock presents a massive aspect.

Above Indian point, which is a long, sandy and gravelly point projecting into the river from the north shore about twelve miles east of Des Joachims rapids, the rocks along the north side show in a continuous series of hills, similar in character to those just described. While the prevailing colour is reddish or reddish-grey, occasional dark hornblendic bands are seen and intrusive dikes of a dark dioritic rock occur at intervals. Along the south side of the river the shores are generally low and sandy, but occasional ledges of similar granite-gneiss appear as far as Des Joachims village. This place is at the head of navigation on the river from Pembroke. On the north side of the village a depression extends westward from the Ottawa which here comes in from the south, and this probably indicates the presence of an old channel of the river, since the water in the present channel to the south is apparently shallow past the chain of the rapids. This point is fifty miles west of Pembroke and the same distance east of Mattawa.

Returning to High View point, at the lower end of the Deep river, the south shore was examined. Similar granite-gneiss was found on all the islands south to the mouth of Sturgeon bay which is at the outlet of the Chalk River chain of lakes, the strike of the foliation being about N. 10° E. with a dip to the northwest at an angle of fifteen

degrees. Similar rocks occupy the south side of the Deep river from High View west for some ten miles, and form a ridge which separates this part of the river from the chain of lakes just mentioned, and which evidently at one time formed an old channel of the Ottawa, now largely filled up with sand and gravels.

The country south from this chain of lakes to Chalk River station and along the Canadian Pacific railway, thence east to beyond the Petawawa river crossing, is largely sand covered. The rocks are exposed at rare intervals and are of the granite-gneiss variety. There is no trace of the limestones of the Grenville series nor of the associated grey gneiss. This granite-gneiss apparently occupies all the country to the north and south of the Ottawa river for many miles, and the Grenville or Hastings series appears to be almost entirely wanting.

Below the head of Sturgeon bay to the mouth of the Petawawa river the shore is composed of high banks of sand. The country south along the line of the railway is a sand plain covered with a small growth of Norway pine, but at the mouth of the Petawawa ledges of foliated granite-gneiss appear similar to that seen along the north shore. Below this the Pembroke channel contains many islets of the red foliated gneiss, and occasional outcrops of the same are seen along the south side almost down to the town of Pembroke. About four miles west of this place there are small outcrops of Calciferous dolomite which represent the western margin of the Palaeozoic basin seen on Allumette island. The shores along this part of the river are generally low and sandy or strewn with boulders.

At Pembroke the Chazy shales, capped by limestones of the upper part of the formation, come in. They continue down the river to the head of the large island at Allumette rapids. This island is composed of a greyish buff-weathering dolomite which probably represents the transition beds between the Chazy limestone and shales.

Descending the Ottawa from Pembroke the principal rock formations on both sides of the river have already been described, as also those seen along the north channel to Bryson.

The south or Roche Fendu channel past Calumet island is very rough, and though at one time used for driving timber has long been given up for this purpose in favour of the north channel. The upper two miles from La Passe to the head of the first dam is through a clay flat, with Calciferous and Chazy limestones and shales on either side.

At Sullivan island, at the head of which is a dam, the rocks are a mixture of granite, gneiss, limestone and pyroxene. The limestone is

generally in small irregular bunches or patches as if caught in the intrusive masses. The associated gneiss is of the rusty variety and sometimes black or reddish grey. The granite is usually massive.

Thence down the north channel past Sullivan island to Desjardin the rocks are mostly granite and granite-gneiss with occasional patches of limestone. Below Desjardin, at the foot of La Fontaine island, the limestone again comes in in force, sometimes well banded but often mixed with granite, and dikes of other rocks in which are crystals of pyroxene, occur. Quartzite and rusty gneiss are also associated. The limestone bands are in places much twisted and broken up, and at the Muskrat portage the intricate admixture of limestone, pyroxene, gneiss and granite forms a very rough surface and almost blocks up the channel, forming a heavy rapid. This limestone is sometimes highly crystalline and white, especially when near the granite intrusions, resembling in this respect much of the Hastings series limestone along the Mississippi river, and the villages of Bryson and Portage du Fort.

Past the Barriere and the Long rapids, which form a very dangerous piece of navigation for canoes, the rocks are mostly limestones underlaid by rusty gneiss with granite dikes, and inclusions of gneiss and pyroxene. From this down to the head of the rapid at the upper end of Roche Fendu lake the limestone occupies the left bank or island shore and the rusty gneiss the right bank with an underlying dip to the north. At the mouth of the upper bay at the head of Roche Fendu lake the gneiss extends across the river, and thence down into the lake the rusty gneiss occupies both sides dipping towards Calumet island at low angles of ten to twenty degrees. At the point above the last carry at the head of the lake a heavy dike of pegmatite cuts the gneiss like a wall and has bent up the rusty gneiss to an angle of about thirty degrees along the contact. It now projects above the surface of the gneiss for several feet.

Along the shores of Roche Fendu lake sands are widely distributed. Ledges of limestone, cut by granite dikes, show at intervals, the former predominating. The islands in the lower part of the lake are mostly of granite, as also the shore to the sharp bend at the junction with the Bryson channel. The islands off the mouth of this channel are mostly of limestone, the contact between the granite and limestone being at the head of the deep bay on the west side below the point.

Thence down the river, for half a mile, limestone occurs along the south shore and in the islands in the stream, succeeded down stream by intrusive granite as far as the wing dam. Here the limestone, with interstratified bands of gneiss, again comes in, and both are cut by

In the western portion of the area included in the map are the Coulonge and Black rivers, both large streams from the north. The former enters the Ottawa at the village of Fort Coulonge in the township of Mansfield, about three miles above the head of Calumet island, while the latter flows into the north or Culbute channel of the Ottawa, near the lower end of Allumette island, in the township of Waltham, about nine miles west of the mouth of the Coulonge.

The area on the south side of the Ottawa is also intersected by several important streams. Of these one of the largest is the Petawawa which rises near the headwaters of the Muskoka river and flows northeast until it meets the Ottawa about nine miles west of the town of Pembroke. For a large part of its course this river has the reputation of being rough and difficult to traverse with canoes. It was, however, surveyed in 1853 by Mr. Alexander Murray of the Geological Survey, who reports that the country thus traversed is largely granitic in character throughout the greater part of its course.

Among other streams which flow into the Ottawa from the south, and are included in the area of the map-sheet, are the Indian and the Musquash rivers, which come in at the town of Pembroke, and the Bonnechére, a large river which joins the Ottawa at a point on Chats lake about twelve miles west of the town of Arnprior. The Madawaska, also an important stream which enters the Ottawa at the latter place, lies to the south of the present map-sheet.

The area north of the Ottawa, with the exception of a belt of townships in the more immediate vicinity of the Gatineau and those adjacent to the Ottawa itself east of the Black river, is almost entirely unopened for settlement. West of the Black River roads extend along the north side of the Ottawa to the deep bay at the lower end of what is known as the Deep river opposite High View, which is at the sharp bend about twenty miles above the town of Pembroke. Roads also extend north nearly to the rear of the township of Sheen, but a large portion of this area is still unopened. Between the Black and Coulonge rivers several settlement roads have been made for a distance of eight to ten miles, and portage roads continue along these streams for some miles farther. In all these townships the travelled roads are in close proximity to the Ottawa. Beyond these the country is generally rough and practically inaccessible outside of the canoe routes along the rivers mentioned.

East of the Coulonge the country is fairly well opened up as far north as the head of Otter lake on the Pickanock river whence a

umber or portage road extends northwest to Squaw lake and thence to the upper part of the Coulonge river.

South of the Ottawa the area between the river and the Bonnechére is much less broken, and good settlements are common. There are here large outcrops of the limestones of the several Palaeozoic formations, the decay of which usually produces a soil very favourable to agriculture, and the crystalline limestones also have a comparatively widespread development as compared with the country north of the Ottawa.

This portion of the map-sheet is also traversed by several lines of railway, among which are the Canadian Pacific from Ottawa westward, the Grand Trunk, and the Pembroke Southern which extends from the town of Pembroke to meet the Grand Trunk at Golden lake. On the north side of the Ottawa the only railway yet constructed, in addition to the line up the Gatineau river, is the Waltham branch of the C. P. R. system, which now terminates near the mouth of the Black river. The Maniwaki branch of the C.P.R. system extends northward, keeping for a considerable part of its course in close proximity to the Gatineau river. This road for some years ended at the village of Gracefield, about one mile above the mouth of the Pickanock, but is now completed to Maniwaki, at the mouth of the Desert river.

The area included in map-sheet No. 122 presents somewhat different geological features from those found in the adjoining map-sheet to the east. In the part near the Gatineau river there is a much greater development of the crystalline limestones belonging to the Grenville or Hastings series than in the western half of the area. This area of calcareous roc' s, while greatly interrupted by masses of granite and occasional outcrops of the grey gneiss, has a breadth from east to west of nearly fifteen miles, and extends northward far beyond the limit of the map-sheet. Its distribution in this direction along the Gatineau river and its tributaries has already been briefly described in the report on map-sheet No. 121.

Westward of the calcareous rocks, the formation is largely granitic in character. These granites are often well foliated, though this feature is also frequently absent. Along the Coulonge river as far north as our examinations along this stream extended, or to a point about seventy miles from its junction with the Ottawa, measured along the stream, large areas of greyish and reddish-grey gneiss are seen. They are

associated with beds of crystalline limestone and quartzite, resembling in this respect the characteristic rocks of the Grenville series. Large portions of this district are covered by heavy beds of sand. The limestone and' quartzite are rarely seen west of the mouth of the Black river.

South of the Ottawa large outcrops or outliers of Palaeozoic rocks, principally Black River limestone, occur, while the western part of this area, especially in the townships of Alice, Fraser, Petawawa and Buchanan, is occupied to a large extent by heavy deposits of clay and sand.

In connexion with the crystalline limestone and associated gneiss found in the district south of the Ottawa there are large areas of crystalline schist. Rusty and yellowish weathering dolomite, often with irregular bunches of quartz, is also a marked feature in the rocks of this district. The schists and dolomite have a wide development along the line of the Kingston and Pembroke railway, being the northern prolongation of large masses of these rocks which are found in the counties of Frontenac and Hastings.

The earliest work on the geology of the district dates back to 1852-53, and was done by Mr. Alexander Murray, the then Assistant Director of the Geological Survey. In the latter year Mr. Murray made a number of traverses and surveys of important rivers in the country south of the Ottawa, comprising the Petawawa from its source near the headwaters of the Madawaska and Muskoka to the junction with the Ottawa above Pembroke; and the Bonnechére from the Ottawa to Round lake which is a few miles west of Golden lake on the Grand Trunk railway. From Round lake a traverse was made across country to the Madawaska River waters, which were reached at what is now known as Barry bay. The geological features of the country adjacent to these rivers were carefully mapped at that time.

In 1853 Mr. James Richardson made a series of surveys in the Pembroke district, including Allumette island, and continued his work east by pacing the road from Pembroke to Ottawa city. Later, in 1876, Mr. L. R. Ord, working with Mr. H. G. Vennor, carried on the work in this area, surveying the greater part of the roads to the north of the Ottawa between Coulonge river and the Gatineau, and on the south side over portions of Westmeath, Ross and Horton townships.

near the Gatineau river for about six miles west to the line of Alleyn township. Rock outcrops are rarely seen in this area. Occasional exposures of red granite are noted but the underlying formation is probably for the most part crystalline limestone. The sand deposits extend north from Kazabazua to the Pickanock river and in fact are continuous to the sandy plains of the River Desert. The country is comparatively level or broken by low elevations.

The evidence of the intrusive character of much of the granite of the Ottawa district through the grey gneiss and associated limestone of the Grenville-Hastings series is very conclusive. There is no doubt as to the later age of portions of the granitic rocks at least. The question of the separation of certain portions of this granite mass under the head of lower or fundamental gneiss is one, however, to be carefully considered. This aspect of the question has been discussed in several recent papers by Messrs. Adams, Barlow and the writer of this report.

From the latest study of the crystalline rocks of the district north of the Ottawa, as well as in the country to the south and west in the counties of Renfrew and Hastings, it would appear that portions at least of the granite-gneiss represent the true fundamental series, and that, owing to softening of the old crust, the newer Grenville and Hastings rocks in places sank down into the lower gneiss, and that the irregular outcrops of the latter now represent the remains of these series that have escaped the enormous denudation which has affected the whole area. In this case it may fairly be assumed that the large areas of the granite-gneiss may be assigned to the Laurentian proper. The presence of other masses, however, may be clearly regarded as true intrusives of later date than the rocks of the Grenville series. Of these several varieties are noticed, such as anorthosite, pyroxenic rocks, pegmatite, diabase and certain granites. Though the latter in many respects resemble physically much of the older granite-gneiss they are as a rule much more limited in extent and tend to a more massive structure. The gneisses associated with the limestones may be regarded as altered sedimentary rocks, their metamorphic characters being due to regional alteration in most cases, but locally more highly altered by the action of the newer intrusives. This feature is frequent in many of the limestones both of the Grenville and Hastings series.

From an examination of all the features of the problem it has now been generally accepted that the Laurentian should be confined as far as practicable to the fundamental granite-gneiss, that the rocks of the Grenville and Hastings series should be regarded as a portion of

the Huronian and represent the lowest members of that system in eastern Ontario and in Quebec adjoining, and that the upper part of the Huronian is represented by the more schistose portion seen in the area farther south and west. In this manner much of the difficulty hitherto experienced in interpreting satisfactorily the great problem of the crystalline rocks disappears.

AREA SOUTH OF THE OTTAWA.

In the district south of the Ottawa there is a greater variety in the rock formations. Large areas or outcrops of the Palaeozoic series are seen at a number of places and these range from the Potsdam to the Trenton.

Exploratory work was carried on in this area at an early period in the history of the Geological Survey. The work of Mr. A. Murray in 1853 on the Bonnechère and the Petawawa rivers, the results of which are given in the Report for 1854, has already been alluded to. In connexion with the examination of the latter stream, which was followed downward from the height of land at the source of the Muskoka, several interesting geological features were brought out.

In character the granite-gneiss, which is the principal rock seen along the Petawawa, as stated by Mr. Murray, is very similar to that seen along the upper Ottawa. He describes it as a "brick-red ferruginous rock composed chiefly of feldspar and quartz, which in some parts has the aspect of an obscure hornblende gneiss, and in others that of a fine-grained syenite; and the gneiss in the vicinity, when the stratification could be distinctly made out, being always shattered and dislocated, I was disposed to consider the red rock intrusive."

As for its distribution along the course of this river Mr. Murray remarks for that portion of the river below Cedar lake, which is forty-five miles in a straight line west from its junction with the Ottawa, "this red rock was seen at intervals from Cedar lake to the mouth of the river, frequently forming bold vertical cliffs which in one instance rose perpendicularly from the river to the height of 250 feet. The rock has a conchoidal fracture and is usually intersected by small greenish coloured veins, supposed to be chlorite, which also penetrate the adjacent gneiss. The black hornblende rock is usually very pyritous, and the associated red masses are frequently highly ferruginous, at times giving a bright red colour to the soil on the surface. Where the gneiss comes in contact with the red rock it often so nearly resembles the adjoining mass that it can only be distinguished from it by closely observing the continuity of the parallel

arrangement of the mineral layers, which ceases at the junction. This was especially observed at the lower end of Cedar lake, where the probability of the mass being intrusive first suggested itself."

"At the northern sweep taken by the river below Lake Travers, (which is about twenty miles below Cedar lake) a portion of the gneiss is dark green, and appears to contain epidote, while other portions are dark-grey, with many disseminated garnets. The fine-grained and supposed intrusive red rock is in close proximity with both these varieties, being seen in the river both above and below where they occur, but whether interstratified with, or intersecting, the gneiss, was not satisfactorily ascertained."

From the above descriptions of the rocks along the Petawawa, which flows approximately parallel to the Deep River portion of the Ottawa at a distance of fifteen to twenty miles south, it would appear that these rocks are continuous across the entire distance, and that there are occasional bands of the greyish and garnetiferous gneiss, but that these are almost entirely removed by denudation or by absorption in the lower or intrusive mass, which some have regarded as the fundamental gneiss. Of the rocks along this river Mr. Murray remarks that "they are so generally affected by dislocations and disturbance, especially below Cedar lake, that the attitude displayed by the stratified portions is not to be relied on, except for short distances."

BONNECHÈRE RIVER.

The examination of the Bonnechère river, which intersects the southern part of the map-sheet from Golden lake to its junction with the Ottawa near Castleford, about twelve miles west of Arnprior, was also made by Mr. Murray in the same year.

This river for the lower part of its course flows between banks of clay with occasional outcrops of the crystalline rocks, but, near the Ottawa, exposures of Calciferous dolomite are seen along the road east of the road bridge and on the shores of the Ottawa river, while considerable areas of the newer formations, including Chazy, Black River and Trenton, occur at intervals nearly to the foot of Golden lake, In this distance the navigation of the Bonnechére is broken by four heavy chutes and by stretches of rapid water.

The elevation of the Ottawa at the mouth of the Bonnechère, taken from Mr. James White's Dictionary of Altitudes, is given as 239·3 feet for low water and 246 feet for high water level in the river. From the same authority the elevation of the water at the outlet of Golden lake is given as 560 feet. This is above mean sea-level.

often swift and in many places broken by heavy rapids and falls which render its ascent difficult for canoes. The upward journey is generally accomplished by taking advantage of a chain of lakes along the west side which extend north for about thirty miles, or, by making several portages and continuing the route through Bryson lake and creek, the main stream can be reached at about seventy-two miles from the mouth, or one and a half miles north of the junction of Crow river, a tributary from the east. Above this point on the Coulonge the ascent of the river is much more easily accomplished.

Along that part of the stream for half a mile on either side of the Crow river grey gneiss, associated with bands of crystalline limestone, is the prevailing rock. The gneiss is sometimes rusty and in places associated with black bands, probably an amphibolite, having a strike of N. 20° W. and dipping N. 70° E. 15°-20°. The limestones appear at several points below, notably at the small bend about two miles above the first fall, which is between the sixty-four and sixty-five mile posts.

This fall is about seven feet high, over dark hornblendic, with reddish and grey, gneiss, the strike and dip of which are the same as just recorded, and this appears to be the general strike of all the rocks throughout this part of the country. The portage past the fall is a fourth of a mile in length, on the west bank of the river, and the gneiss and limestone are here abruptly cut off by a mass of red granite. A conglomerate band is seen in the limestone a short distance above the falls, the pebbles consisting of red and grey gneiss, well rounded and stuck in the limestone at all angles. The resemblance of these pebbles to the rocks of the Grenville series, as also to those of the Hastings series as seen along the Mississippi river, is very marked.

At this fall a steep granite mountain rises to the west of the stream, but below this as far as Devil chute, almost twelve miles farther down the river, the shores are generally low and for the most part consist of sand and gravel. Occasional outcrops of the usual gneiss appear with a dip of N. 80° E. $<$ 60°-80°. The same dip is seen at the Chute in greyish and black gneiss which is cut by granite dikes. Small bands of limestone with inclusions of rusty gneiss are found at many of the gneiss outcrops. In places the limestone is quite dolomitic and weathers a buff-yellow. High ridges of granite-gneiss occur along the east bank of the river, between the main stream of the Coulonge and the east branch.

Below this for some miles the course of the river is much more crooked. The exposed rocks are usually of the gneissic variety, for

to the west of the outlet there are outcrops of crystalline limestone. On the shore along the line of the Grand Trunk railway a mass of red granite, seen in a cutting, traverses the gneiss and limestone and should, therefore, be of subsequent date.

The south shore of the lake shows occasional outcrops of the gneiss to the mouth of Brennan creek which flows in near Killaloe station on the Grand Trunk. Masses of granite cut the gneiss at many points and break the continuity of the banded series. Along the railway the cuttings are for the most part in sand and gravel, but near Killaloe well banded gneiss appears to dip S. 50° E. $<$ 35°-50°. The west end of Golden lake is low and somewhat marshy and ledges are not seen.

A high ridge of gneiss rises along the north side of the Bonnechère above Golden lake, which towards Round lake recedes to the north-west. The area to the south is low.

Around the shores of Round lake the rocks are largely concealed by sand. A ridge of red granite-gneiss appears at the upper end where the Bonnechère enters the lake with a dip of S. 80° E. $<$ 15°. This is a foliated granite resembling the fundamental gneiss. The south side of the lake is all well stratified sand and gravel in low cliffs, and a range of hills, probably of granite-gneiss, rises a short distance inland.

The intrusive character of much of the granite is well seen in the area along this portion of the Bonnechère waters. No trace of limestone was recognized west of the small ledges in the lower end of Golden lake.

The western townships in this area, including North and South Algoma, Fraser, Alice, MacKay, Petawawa, Buchanan and Wilberforce are occupied to a large extent by sand deposits. These are underlaid by clays in which no trace of marine organisms have as yet been found. The underlying rock where exposed is for the most part gneiss. The limestone is not exposed west of the township of Wilberforce where the last outcrops in this direction were observed along a road from Golden lake to the west end of Lake Doré, though occasional areas of the calcareous rocks may lie concealed beneath the drift. It would appear, however, that this area is occupied generally by the gneissic-granites which have been described in the area along the Petawawa and the upper Ottawa.

Farther east, however, in the townships of Ross, Horton and MacNab, the limestones are well developed. These appear to be a por-

tion of the great Gatineau belt of the north side of the Ottawa which has been cut off in part by the great granitic mass of the King Mountain ridge and its extension west into Clarendon township.

In the areas south of the Ottawa the limestone presents features somewhat different from those seen in the Gatineau and Grenville district. It has frequently a banded aspect from the presence of minute layers of finely comminuted graphite, and this banded or striped feature is found in much of the calcareous division south of the Ottawa, so much so that the name "striped limestone" is frequently employed to distinguish these rocks.

They are also associated with bands of hornblende schistose rock and frequently with mica schists which are a pronounced feature farther south along the line of the Kingston and Pembroke railway. A portion of this schistose series crosses the Ottawa above the Chats falls and is seen near the Bristol iron mines and along the line of the old horse railway past the falls and rapids, associated with epidotic and hornblende rocks. A large portion of the southern area is occupied by outliers of Palaeozoic formations.

About Renfrew the limestones of this character are well displayed, as also to the north in the area between this place and Portage du Fort. While these are cut in many places by masses of granite and other intrusive rocks, they are also associated with areas of greyish gneiss and hornblende schists. The limestones are, as a rule, more dolomitic and are in places highly tremolitic, a feature well seen along the line of the Kingston and Pembroke railway between Renfrew and Calabogie lake. This feature is also seen in some parts of the Gatineau district. Some of the limestones, as in the township of Ross, are true crystalline dolomites with more than forty per cent of magnesian carbonate. This rock should be well adapted for the manufacture of chemical pulp. The schistose portion of these rocks, which have been described in Reports by Vennor under the head of the Hastings series, (Ann. Rep. 1876-77) is much more extensively developed in the southern part of Renfrew county and in the counties of Frontenac and Lanark adjacent to the south.

Much information is given in Vennor's report already mentioned regarding the distribution of the various gneisses and crystalline limestones in the county of Pontiac north of the Ottawa river, (See pages 277-296.) It is scarcely necessary to repeat the descriptions of the rocks found in this area, since the conclusions regarding the structure have since that date been very considerably modified, and their physical features have been discussed in the Report on the Grenville mapsheet.

PALAEOZOIC FORMATIONS.

The Palaeozoic rocks found in the area of the accompanying map-sheet range from the base of the Calciferous to the Trenton limestone. They form the remnant of the western margin of the great Ottawa basin and are found at intervals along the Ottawa and also as scattered outliers in the townships of Bromley, Stafford and Wilberforce, as well as at a number of points along the Bonnechère river. Near Ottawa city they occupy the north shore of the river in Hull and a part of Eardley townships, and on the south side are seen along the river in March, Torbolton and Fitzroy townships. A small outcrop of Calciferous dolomite is seen about two miles northeast of the village of Portage du Fort resting upon granite and diorite rocks, by which they have apparently been somewhat altered.

POTSDAM AND CALCIFEROUS.

The only outcrops of the Potsdam yet recognized in this area are in the rear of the village of Quio on the north bank of the Quio river. Granite-gneiss occupies the bed of the stream at the mill on the road crossing, but a short distance above this the Potsdam shows in low ledges overlaid by Calciferous dolomite. A quarry has been opened in the sandstone and the rock is used locally for building purposes. The strata are in a horizontal attitude.

The area along the Ottawa river between Hull and the foot of Chats falls, of which the outcrops near Quio represent the northern margin, is basin-shaped. The Calciferous dolomite just described shows along the north shore of the river from a point fifteen chains east of the latter village, both along the road and in occasional outcrops on the shore, while the formation is overlapped by the Chazy shales in the village itself. The Calciferous is here exposed along the road for fifty chains, resting in thin strata upon granitic rocks where it fills up inequalities of the surface, the sandstone being absent at this place. Much of the shore east of this where rock exposures are seen is occupied by granite, but this is often concealed by marine clays, in which nodules like those of Greens creek are found, containing the skeletons of fishes.

Below the mouth of Breckenridge creek, which is about seven miles west of Aylmer, a narrow margin of the dolomite occupies the shore beneath the Chazy shales with an exposed breadth of several hundred yards inland, and shows as far east as the Cedars a mile west of that village, when the Chazy reaches the shore and continues east nearly to Tetreauville.

On the south shore of the river the Calciferous dolomite comes into view about two miles west of Britannia and is thence seen to within

a mile and a half of Berry wharf where it passes upward into the basal beds of the Chazy formation which is here a coarse sandy grit. The dolomite is seen along the roads in the western portion of Nepean township underlaid by the Potsdam sandstone ; and also about South March corners. From this place it is exposed along the road west to Dunrobin post office, and it also occupies much of the flat country between this road and Constant creek in the direction of Berry wharf until it is covered by the rocks of the Chazy formation.

Along the shore of the Ottawa the Chazy shales extend west to a point about two miles beyond Berry wharf and here pass up into the Chazy limestone through transition beds which have a thickness of about twenty feet. The Chazy limestone then continues for about ten miles but gives place to the shales about three miles east of the Ferry landing opposite Quio village. The Chazy limestone outcrops inland and is capped by the Black River formation in the northwest portion of Torbolton, which forms the summit of the escarpment in this direction. The shales continue along the shore to near the mouth of Carp river, a short distance below the village of Fitzroy Harbour, where the Calciferous dolomite again comes to the shore and here rests upon the crystalline rocks which form the Chats falls.

While the strata along this part of the Ottawa are all nearly horizontal, several low anticlines are seen at intervals. Heavy deposits of sand occur about the mouth of Constant creek and around Big and Sand bays. This basin of Palaeozoic rocks is bounded on the south by a ridge of granite gneiss and crystalline limestone which extends east from the foot of Chats falls through the northern portion of the townships of Fitzroy, Huntley and a portion of March into the western part of Nepean, terminating about ten miles west of Ottawa city.

The difference in elevation between the foot of the Chats falls and the lake expansion of the river at the head of the rapids has already been stated as about fifty feet, the distance being three and a half miles. The Calciferous dolomite is seen along the shores of the river above the rapids resting upon the gneiss and crystalline limestone. The Chazy shales come into view about two miles west of the town of Arnprior. There would, therefore, appear to be a vertical uplift of the strata for at least fifty feet, and probably even more than this amount. That such an uplift has taken place in the area south of the river is also probable from the fact that the Potsdam sandstone seen at the Quio village is found on the summit of the ridge of crystalline rocks in the northern part of the township of Fitzroy at an elevation of several hundred feet above the river level.

On the north side of the Ottawa the Calciferous dolomite is distributed in irregular patches on the crystalline rocks nearly to Norway bay, opposite the village of Sand Point, which is on the south side of the river. It shows in several small islands in the river and on the south side is seen above Sand Point near the mouth of the Bonnechère, and for several miles east of that place in flat ledges along the shore until it is capped by the rocks of the Chazy formation. The regularity of the strata is much affected in this area by the presence of several faults; one of which is seen in the west part of the town of Arnprior where the Calciferous dolomite is in contact with limestones of the Hastings series, and a deposit of red hematite which has been mined in former years occurs along the line of contact.

Above the mouth of the Bonnechère the Calciferous rocks are not exposed, the crystalline limestone and gneiss appearing along the shore on both sides of the Ottawa, with the exception of the small outliers to the east of Portage du Fort.

The outcrops of the Calciferous in this area are so detached that no estimate as to the thickness of the formation has been attempted. It is, however, much less in apparent volume than in the outcrops along the lower portion of the Ottawa river.

CHAZY.

The division of this formation into a lower portion embracing the sandstones and shales, and an upper part consisting of limestones, has been made wherever practicable.

Measurements were made to determine the thickness of this portion in the area on the south side of the Ottawa below Fitzroy Harbour in the escarpment opposite Quio village where the shales are well developed. The base of the formation is beneath the water but there are about 100 feet of shales exposed in the rise south of the river to the passage into the overlying limestones, so that if an additional amount of twenty-five feet be allowed for the portion from Quio village to the south shore the total thickness of the lower division of shales would be about 125 feet. This would not differ much from the estimated thickness at Aylmer.

The thickness of the limestone division could not be ascertained here, but an estimate of the thickness on the roads east of Fitzroy Harbour gave a volume for the upper member of the formation of not far from 100 feet to the base of the fossiliferous Black River limestone.

The distribution of the Chazy in the basin west of Ottawa has already been given to a large extent under the head of Calciferous. Along the ridge south of Berry wharf the shales so well seen along the shore are capped on the crest of the rise by the limestones of the upper division, while the shales again appear in the valley of Constant creek to the south. The shales show east of Fitzroy Harbour in the slope of the hill beyond the Carp river, and are here capped by the limestone along the roads which cross the escarpment to the north-east.

Above Arnprior the contact of the Chazy shales with the Calciferous on the shore is seen about half a mile east of Braeside, the underlying Calciferous dolomite dipping southwest $< 2°$. The shales are thence exposed along the shore and in the hills to the south for several miles and form the steep ascent south of Sand Point, the upper part of which is capped by Chazy limestone which passes up into the Black River formation along the top of this ridge, the surface breadth being nearly a mile and a half.

The shales are also seen along the Canadian Pacific railway west of Sand Point station until they are terminated by the underlying Calciferous of the area east of the Bonnechère river, near Castleford station.

Outcrops of this formation are seen along the Bonnechère at several points. They are well exposed at the third chute near Douglas village and for several miles along the stream westward towards the fourth chute where they are overlapped by the Chazy limestones. They also show in the river at Eganville but the areas here are somewhat faulted and the outcrops are abruptly terminated.

Along the upper Ottawa they have already been referred to as occurring on Allumette island and on the west end of Calumet island. They are seen also along the eastern shores of Lake Doré where they form the lowest member of an outlier of these rocks which pass upward into the Black River formation.

BLACK RIVER AND TRENTON LIMESTONE.

The outcrops of this formation in the area south of the Ottawa are quite numerous and are widely distributed. They occur sometimes as isolated outliers with boldly scarped sides, at other places they represent the upward passage from the Chazy limestones, as in the area east of Fitzroy Harbour and to the north of the town of Aylmer.

Along the south side of the Ottawa river the Black River limestone is seen on the ridge south of Buckham bay which is about six miles

east of Quio. The Chazy linestone occupies the shore at this place, and the Black River formation has here been extensively quarried. Large quantities of excellent stone were removed for the construction of the old canal past the Chats falls about forty years ago, and later for bridge construction on the Pontiac and Pacific railway. The limestones of this formation have a considerable development in the northern portion of Torbolton township and pass into the *Receptaculites* beds which represent the lowest portion of, or transition beds to, the Trenton formation proper.

Ascending the Ottawa river the Black River formation is next seen on the top of the ridge south of Sand point about five miles west of Arnprior. The rocks here are highly fossiliferous and certain bands hold an abundance of *Tetradium fibratum*, a characteristic fossil of these limestones. These rocks form the crest of a ridge extending south for over a mile from the river, and on the south flank, which drops somewhat abruptly to the clay flat inland, are several quarries from which also fossils peculiar to the formation have been obtained.

The continuation of these rocks westward can be traced for several miles. They show on the crest of a ridge south of the river near the line between MacNab and Horton townships where they also overlie the Chazy limestone. These rocks are readily recognized by their peculiar physical aspect, weathering in broad, jointed, flaggy, thick masses, and in most cases contain fossils which are mostly determinable.

In the townships of Bromley and Wilberforce a large area of this limestone is found. It extends from the east side of Lake Doré in a southeast direction for about eleven miles with a breadth in places of nearly three miles, overlaid in part by limestones of Trenton age. The outcrops cannot be traced continuously, however, owing to great areas of drift. On the south side of the Bonnechére they form a ridge which rises a short distance from the village of Douglas near the crest of the hill crossed by the road thence to Renfrew, and here cap the Chazy limestone. The Black River limestone extends east from this place for nearly three miles, showing along the road in broad bare ledges, which is a feature generally seen in outcrops of these rocks, their massive character being in marked contrast to the softer and more easily decomposed strata of the overlying Trenton.

Another conspicuous area of these bare rocks is seen to the southeast of Eganville where it is crossed by the Grand Trunk railway. An estimate of the thickness of the limestones at this place gave not far from 100 feet.

The distribution of the Chazy in the basin … of this limestone,
already been given to a large extent under … outh of Muskrat lake
Along the ridge south of Berry wharf th… ne north and west, and
the shore are capped on the crest of th… Large quarries are found
upper division, while the shales agai… e railway near the Muskrat
creek to the south. The shales … e been collected.
slope of the hill beyond the C… Calumet island the Black River lime-
limestone along the roads … out three miles west of Coulonge village,
east. … the boom about three miles farther west.

Above Arnprior … both places from which collections have been
ferous on the sh… Fossils are found at
underlying C… The outcrops at the foot of Allumette island (Paquette rapids) have
are thence… already been referred to.
several…

Several other isolated outcrops of these rocks are seen in the area south of Bonnechére. They are beyond the limits of the map-sheet and may be referred to merely as showing the widespread character of the rocks before their removal by denudation. They are found on the west side of Clear lake, and on the road east of this towards Dacre near the crossing of Constance creek. On the shores and roads around Calabogie lake also these rocks are seen, all indicating a wide expansion of the rocks of the Ottawa Palaeozoic basin in this direction at some early time. The more recent formations which now occur near the city of Ottawa have all been removed with the exception of a small area, near Clear lake, of Utica shale.

Several large collections of fossils, chiefly from the outcrops of the Black River formation, were made by Mr. L. M. Lambe and the writer, in 1896. These have been determined by Mr. Lambe, and the lists from the several localities are here given.

From Stewart's quarry on lot 19, range XI, and from Gillies quarry, lot 2 , range B, township of McNab.

Columnaria halli, Nicholson.
Tetradium fibratum, Safford.
Monotrypella trentonensis, Nicholson, (sp.)
Leperditia canadensis, Jones.
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Orthoceras, sp.

From hill behind Sand Point village, lot 18, range A, same township.

Columnaria halli, Nicholson.
Tetradium fibratum, Safford.

Crinoid stems, (remains of)
Leperditia canadensis, Jones.
Bathyurus extans, Hall. (caudal shield of small specimen).
Asaphus platycephalus? Stokes. (portion of caudal shield).
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Rhynchotrema inaequivalvis, Castelnau=*R. increbescens*, Hall.
Zygospira recurvirostra, Hall, (sp.)
Murchisonia gracilis, Hall.

From quarry on hill south of Douglas village, lot I, range VIII, Bromley township.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Tetradium fibratum, Safford.
Crinoid stems, (remains of)
Pachydictya acuta, Hall. (sp.)
Orthis pectinella, Conrad.
Ctenodonta astartiformis, Salter.
Strophomena incurvata, Shepard.
Zygospira recurvirostra, Hall.
Actinoceras bigsbyi, Stokes.

From Cobden road, one mile and a half northwest of Douglas, lot 10, range VIII, Bromley township.

Stromatocerium rugosum, Hall.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments)
Leperditia canadensis, Jones.
Orthoceras multicameratum ?, Emmons.

Forks of road to Cobden, lot 12, range VII, Bromley township.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Tetradium fibratum, Safford.
Crinoid stems, (fragments)

Cross roads, lot 16, range VI, Bromley township, four miles south of Cobden.

Solenopora compacta, Billings. (sp)
Streptelasma corniculum, Hall.
Protarea vetusta, Hall. (sp.)

In the township of Stafford an important outlier of this limestone, occupying several square miles, is seen to the south of Muskrat lake and river. It has steeply scarped sides on the north and west, and rests on the Chazy limestones on the south. Large quarries are found on the northwest flank overlooking the railway near the Muskrat Lake crossing, from which fossils have been collected.

Along the Ottawa river above Calumet island the Black River limestone is seen at Séche point about three miles west of Coulonge village, and at the point below the boom about three miles farther west. Fossils are found at both places from which collections have been made.

The outcrops at the foot of Allumette island (Paquette rapids) have already been referred to.

Several other isolated outcrops of these rocks are seen in the area south of Bonnechére. They are beyond the limits of the map-sheet and may be referred to merely as showing the widespread character of the rocks before their removal by denudation. They are found on the west side of Clear lake, and on the road east of this towards Dacre near the crossing of Constance creek. On the shores and roads around Calabogie lake also these rocks are seen, all indicating a wide expansion of the rocks of the Ottawa Palaeozoic basin in this direction at some early time. The more recent formations which now occur near the city of Ottawa have all been removed with the exception of a small area, near Clear lake, of Utica shale.

Several large collections of fossils, chiefly from the outcrops of the Black River formation, were made by Mr. L. M. Lambe and the writer, in 1896. These have been determined by Mr. Lambe, and the lists from the several localities are here given.

From Stewart's quarry on lot 19, range XI, and from Gillies quarry, lot 2 , range B, township of McNab.

Columnaria halli, Nicholson.
Tetradium fibratum, Safford.
Monotrypella trentonensis, Nicholson, (sp.)
Leperditia canadensis, Jones.
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Orthoceras, sp.

From hill behind Sand Point village, lot 18, range A, same township.

Columnaria halli, Nicholson.
Tetradium fibratum, Safford.

Crinoid stems, (remains of)
Leperditia canadensis, Jones.
Bathyurus extans, Hall. (caudal shield of small specimen).
Asaphus platycephalus ? Stokes. (portion of caudal shield).
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Rhynchotrema inaequivalvis, Castelnau=*R. increbescens*, Hall.
Zygospira recurvirostra, Hall, (sp.)
Murchisonia gracilis, Hall.

From quarry on hill south of Douglas village, lot I, range VIII, Bromley township.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Tetradium fibratum, Safford.
Crinoid stems, (remains of)
Pachydictya acuta, Hall. (sp.)
Orthis pectinella, Conrad.
Ctenodonta astartiformis, Salter.
Strophomena incurvata, Shepard.
Zygospira recurvirostra, Hall.
Actinoceras bigsbyi, Stokes.

From Cobden road, one mile and a half northwest of Douglas, lot 10, range VIII, Bromley township.

Stromatocerium rugosum, Hall.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments)
Leperditia canadensis, Jones.
Orthoceras multicameratum ?, Emmons.

Forks of road to Cobden, lot 12, range VII, Bromley township.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Tetradium fibratum, Safford.
Crinoid stems, (fragments)

Cross roads, lot 16, range VI, Bromley township, four miles south of Cobden.

Solenopora compacta, Billings. (sp)
Streptelasma corniculum, Hall.
Protarea vetusta, Hall. (sp.)

At top of north slope of hill southwest of Cobden, lot 16, range VI, Bromley township.

Probably lower beds of Trenton or transition.

Receptaculites occidentalis, Salter.
Asaphus (*Isotelus*) *maximus*, Locke,=*A megistos*, (portion of cephalic shield.)
Ceraurus pleurexanthemus, Greene, (cephalic shield.)
Ptilodictya maculata, Ulrich.
Orthis testudinaria, Dalman.
Orthis pectinella, Conrad.
Strophomena incurvata, Shepard.
Rhynchotrema inaequivalvis, Castelnau.
? *Pterinea elliptica*, Hall. (sp.)

Munroe's quarry, lot 19, range 2, Westmeath tp.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Tetradium fibratum, Safford.
Crinoid stems, (fragments)
Strophomena incurvirostra, Shepard.
Camerella panderi, Billings.
Murchisonia bellicincta, Hall.
Murchisonia gracilis, Hall.
Actinoceras bigsbyi, Stokes.
Orthoceras, sp.

Ridge south of Mud creek, lots 12-13, range 11, Stafford township.

Solenopora compacta, Billings, (sp.)
Receptaculites occidentalis, Salter.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments.)
Strophomena incurvata, Shepard.
Rhynchotrema inaequivalvis, Castelnau.
Ctenodonta contracta, ? Salter.
Pleurotomaria progne, Billings.
Pleurotomaria subconica, Hall.
Murchisonia bellicincta, Hall.
Murchisonia gracilis, Hall.
Bellerophon sulcatinus, ? Emmons.
Maclurea logani, Salter.
Orthoceras, sp.
Cyrtoceras falx, Billings.

From quarry near Eganville, lot 18, range VIII, Wilberforce township.

Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments.)
Asaphus platycephalus, (caudal shield), Stokes.
Monotrypella trentonensis, Nicholson, sp.
Escharopora recta, Hall.
Stictopora acuta, Hall.
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Plectambonites sericea, Sowerby.
Rhynchotrema inaequivalvis, Castelnau.

From loose specimens near quarry.

Streptelasma corniculum, Hall.
Calapœcia canadensis, Billings.
Batostoma ottawaensis, Foord.
Orthis testudinaria, Dalman.

From boulders on ridge south of Clear lake.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Calapœcia canadensis, Billings.
Orthis testudinaria, Dalman.
Maclurea logani, Salter.

SURFACE GEOLOGY.

The surface geology of this district is characterized by the same atures as described for the map-sheet adjacent on the east. Great eas of clays, sands and gravels are conspicuous at many points. ome of these show their marine origin by the presence of shells, the mains of fishes, &c., while other large areas apparently on the same rizon are destitute of such organisms.

Clays are well exposed in the eastern portion of the area along the atineau Valley railway as far north as Venosta, beyond which the eat extent of sand known as the Kazabazua plains comes in, and e clays are largely concealed. In fact a great part of the northern lf of the map-sheet shows these sands over many miles from the atineau river across the Black and Coulonge rivers and out to the Ot- wa at the foot of the Deep river, where they cross and are seen on the uth side in the Chalk and Petawawa River plains. These sand plains, oken by occasional rocky ridges, extend south beyond the Bonnechère.

granite masses similar to those seen on the east end of Calumet island. Below this to the bridge near Portage du Fort the rocks are a mixture of granite, gneiss and limestone, the whole intricately involved, and the intrusive nature of the former is clearly seen. At the bridge and along the south side of the river anorthosite masses and dikes form a prominent feature, and thence to the lower end of the large island at Portage du Fort these rocks cut the limestone at many points, the latter forming the east end, and continuing down stream for several miles past the Cheneau rapids. On the south shore the limestones are interstratified with the gneiss, and a mass of anorthosite several square miles in extent is seen along the roads leading to Haley station and to Renfrew. All along this portion of the river the limestones are highly altered and much contorted, with numerous dikes of granite and diorite.

AREA NORTH OF THE OTTAWA.

PICKANOCK RIVER.

The principal branch of the Gatineau from the west in this area is the Pickanock river. It joins the former near the northeast angle of the sheet and rises in several large lakes, the most important being Lake Dumont. For a great part of its course the banks of this stream show no ledges, the shores being low and sandy. The country to the north is practically unopened for settlement and the surface in this direction is frequently occupied by heavy deposits of sand. Where the underlying rocks are exposed they consist of granite and granite-gneiss and occasionally thin beds of greyish gneiss and crystalline limestone outcrop. One of the bands of the latter is seen on the road up the west side of the Pickanock in the township of Clapham. A traverse was made along this stream and an examination was also made of the lakes at its head, including Squaw, Du Mont and the Kegimaw lakes.

Around these the rocks are mostly granitic. At the east end of Du Mont lake a small exposure of pyroxenic rock was observed but no minerals of value were noticed in connexion with the outcrop. Around the Kegimaw lakes the shores are of sand and gravel, but a narrow band of limestone comes into view at the north end of the upper lake and extends across to the headwaters of the south branch of the Desert river. Ridges of granitic rock traverse the district, but much of the country is densely wooded and rock exposures are few.

In the townships of Low and Aylwin large areas are also occupied by deposits of sand and clay. Among the most extensive of these are the Kazabazua plains which extend from the village of Kazabazua

From quarry near Eganville, lot 18, range VIII, Wilberforce township.

Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments.)
Asaphus platycephalus, (caudal shield), Stokes.
Monotrypella trentonensis, Nicholson, sp.
Escharopora recta, Hall.
Stictopora acuta, Hall.
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Plectambonites sericea, Sowerby.
Rhynchotrema inaequivalvis, Castelnau.

From loose specimens near quarry.

Streptelasma corniculum, Hall.
Calapœcia canadensis, Billings.
Batostoma ottawaensis, Foord.
Orthis testudinaria, Dalman.

From boulders on ridge south of Clear lake.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Calapœcia canadensis, Billings.
Orthis testudinaria, Dalman.
Maclurea logani, Salter.

SURFACE GEOLOGY.

The surface geology of this district is characterized by the same features as described for the map-sheet adjacent on the east. Great areas of clays, sands and gravels are conspicuous at many points. Some of these show their marine origin by the presence of shells, the remains of fishes, &c., while other large areas apparently on the same horizon are destitute of such organisms.

Clays are well exposed in the eastern portion of the area along the Gatineau Valley railway as far north as Venosta, beyond which the great extent of sand known as the Kazabazua plains comes in, and the clays are largely concealed. In fact a great part of the northern half of the map-sheet shows these sands over many miles from the Gatineau river across the Black and Coulonge rivers and out to the Ottawa at the foot of the Deep river, where they cross and are seen on the south side in the Chalk and Petawawa River plains. These sand plains, broken by occasional rocky ridges, extend south beyond the Bonnechère.

They occupy large portions of Alice and Fraser townships and are conspicuous features around Golden and Round lakes.

East of the Ottawa river, from Portage du Fort to Bryson, they are found throughout the southern part of the townships of Clarendon and Bristol. The sands are reddish and probably derived from the decay of the granites and gneiss of the northern country, while the clays underlying are presumably due to the decay of the Palaeozoic limestones which probably once occupied all the country now forming the basin of the Ottawa, the scattered remains of which are seen in the outliers already described.

The surface geology of the area along the valley of the Ottawa has been well described by Dr. R. Chalmers in the Report for 1897, and lists of striae have been there given. From his observations, as also from other notes pertaining to the area to the north and south, it appears that three sets of ice markings can be recognized along the river. Among these may be mentioned the following

NORTH OF THE OTTAWA RIVER near Sheenboro P.O.		S. 25° E.
Two miles west of Waltham P.O.		S. 60° E.
Chichester, opposite Pembroke		S. 29° E.
Road two miles N. E. of Vinton P.O.		S. 30° E.
Shore road about four miles E. of Portage du Fort	S. 30° E.	S. 15° E.
Near Parkman P.O. two miles N.E. of Portage du Fort		S. 30° E.
Road one mile east of Billerica P.O.		S. 55° E.
Road half a mile west of Wakefield P.O.		N. and S.
SOUTH OF THE OTTAWA RIVER—		
Near mouth of Petawawa river		S. 25° E.
East line of Ross, two miles south of river		S. 20° E.
Road south side of river, one mile west of Portage du Fort bridge		S. 45° E.
Four miles south of Cobden		S. 20° E.
Roads between Cobden and Lake Doré		S. 40° E.
In vicinity, on several outcrops	S. 25° E.	S. 40° E.
West part of Westmeath township		S. 30° E.
Near Stafford post-office		S. 30° E.
Garden of Eden, east part of Horton township		S. 42° E.
On road near Forester falls, "		South.
One mile southeast of Forester falls		S. 15° E.
Two miles west of Healy station, C.P.R.		S. 40° E.
One mile N.W. of Lake Doré		South.
Two miles N.W. of Lake Doré		S. 10° W.
Near Rankin post-office		S. 10° W.
One mile N.E. of Doré lake		South.
South side of Mink lake		S. 10° W.
Southeast end of Mink lake on road		S. 10° E.
Road north of Mud lake, Bonnechére river		S. 30° W.
Road Eganville to Clear lake, midway		S. 35° W.
Near Alice post-office		S. 10° E.
Near Renfrew		S. 55° E.
South side of Golden lake on road		S. 25° W.

arrangement of the mineral layers, which ceases at the junction. This was especially observed at the lower end of Cedar lake, where the probability of the mass being intrusive first suggested itself."

"At the northern sweep taken by the river below Lake Travers (which is about twenty miles below Cedar lake) a portion of the gneiss is dark green, and appears to contain epidote, while other portions are dark-grey, with many disseminated garnets. The fine-grained and supposed intrusive red rock is in close proximity with both these varieties, being seen in the river both above and below where they occur, but whether interstratified with, or intersecting, the gneiss, was not satisfactorily ascertained."

From the above descriptions of the rocks along the Petawawa, which flows approximately parallel to the Deep River portion of the Ottawa at a distance of fifteen to twenty miles south, it would appear that these rocks are continuous across the entire distance, and that there are occasional bands of the greyish and garnetiferous gneiss, but that these are almost entirely removed by denudation or by absorption in the lower or intrusive mass, which some have regarded as the fundamental gneiss. Of the rocks along this river Mr. Murray remarks that "they are so generally affected by dislocations and disturbance, especially below Cedar lake, that the attitude displayed by the stratified portions is not to be relied on, except for short distances."

BONNECHÈRE RIVER.

The examination of the Bonnechère river, which intersects the southern part of the map-sheet from Golden lake to its junction with the Ottawa near Castleford, about twelve miles west of Arnprior, was also made by Mr. Murray in the same year.

This river for the lower part of its course flows between banks of clay with occasional outcrops of the crystalline rocks, but, near the Ottawa, exposures of Calciferous dolomite are seen along the road east of the road bridge and on the shores of the Ottawa river, while considerable areas of the newer formations, including Chazy, Black River and Trenton, occur at intervals nearly to the foot of Golden lake, In this distance the navigation of the Bonnechére is broken by four heavy chutes and by stretches of rapid water.

The elevation of the Ottawa at the mouth of the Bonnechère, taken from Mr. James White's Dictionary of Altitudes, is given as 239·3 feet for low water and 246 feet for high water level in the river. From the same authority the elevation of the water at the outlet of Golden lake is given as 560 feet. This is above mean sea-level.

ably equipped. There are now in place two Taylor Langdon roasters, and one Westman kiln, modified by Mr. Ernest Sjöstedt, resembling in many points what is known as the Davis Kolby kiln. These kilns are operated by gas generated in Langdon producers. The mine has been opened to a depth of 150 feet, with drifts along the strike of 150 feet and across the vein of fifty feet in one place and thirty and sixty feet in length in another locality, while test-pits and magnetic surveys indicate a deposit of considerable magnitude. The following analyses show the composition of the ore both raw and calcined.

Raw.

	A.	B.	C.
Iron	58.37	62.15	61.987
Sulphur	1.46	0.97	2.406
Phosphorus	trace	.0075	.006
Silica	11.45	8.52	7.32
Lime	3.91		

Roasted.

	D.	E.	F.	G.
Iron	62.5	62.525	62 87	63.24
Sulphur	0.521	1.1673	2.221	1.08
Phosphorus	.004		0.014	

A. Geological Survey of Canada.
B. R. Richards, Boston.
C. Booth, Garrett and Blair.
D. Lackawanna Iron and Coal Co.
E. A. McGill, Ottawa.
F. and G. Troy Iron and Steel Co.

The latest experiments with the roasters show, according to Mr. McGill's analyses, that the sulphur was reduced to 0·279.

Further remarks on the treatment of these ores will be found in the Annual Report of the Geological Survey, 1888–89, on "Mineral Resources of Quebec."

Indications of other deposits of ore are found in connexion with this belt of rocks between this locality and the shore of the Ottawa near the ferry to Braeside. These iron bearing rocks here form a somewhat extensive belt, and pockets of the ore have been reported as occurring in this direction, though the area has apparently never been properly prospected.

Indications of iron ore are found at several points in the township of Litchfield and also on Calumet island. Those seen have no great surface development and some at least are presumably of but little

economic value. It is quite possible, however, that in the great belt of granitic and dioritic rocks which occur in this area other bodies as important as those at Bristol may be found.

Galena and Blende.

The principal deposits of these minerals are found near the eastern end of Calumet island. Mining has been carried on here for some years at irregular intervals on pockety masses of zinc blende and galena which occur in connexion with dioritic and granite rocks. These cut across the rusty gneiss and crystalline limestone of the district. There does not appear to be any true vein structure to these deposits of ore, some of which are of large size yielding several hundred tons of shipping material, but much of the output requires careful cobbing and concentrating to be profitably handled.

These deposits have been referred to in several of the summary reports on this district and analyses of the galena have been given. All work has been suspended on this property for several years.

In the southern part of the island, on lots 12 and 13 of range IX, some work was done, and in 1898, was continued on a mass of pyritous ore which held in places a small percentage of nickel. The ore occurred in connexion with dikes of diorite which traverse the rusty gneiss and limestones of the Roche Fendu channel of the Ottawa river, and the outcrop was marked by a similar rusty covering to that seen at the blende mines farther east.

A shaft was sunk on the deposit to a reported depth of over seventy feet, but the quantity of the mineral was not sufficient for economic development and the work was abandoned. Indications of similar minerals are seen at several places on the island in connexion with intrusive masses through the grey and rusty gneiss, but the deposits in the eastern portion appear to be the most extensive.

Mica.

The development of the Mica industry has been confined to the last fifteen years. At the time of the publication of the Report on the Mineral Industries of Quebec," 1888-89, no mines of this mineral were being operated in the province or, if so, on a very limited scale. The mode of occurrence has already been fully discussed in previous reports and attention need only be directed to the localities where workable mines are in operation. (See Bulletin on Mica, 1904.)

Of these the most important mineral belt is confined to the town ships adjacent to the Gatineau river. Farther west occasional deposits

have been reported and some of these have been worked to a limited extent though without very satisfactory results.

One of these deposits is located in the southwest corner of the township of Huddersfield near the outlet of Hickey lake about twelve miles back from the village of Coulonge. The country rock at this place is a black and reddish-grey gneiss much broken up by intrusive granite masses. At the mine dikes of very dark pyroxenic rock occur in which the mica, which is also very dark coloured, is found. Some of the crystals are of good size, but are much affected by cracks, so that the output of good mica is very small. Dikes of pegmatite also cut the rocks at this place. Masses of pinkish calcite also occur and in these are scattered crystals of apatite. No work has been done here for some years.

In the northern portion of the township of Litchfield, in rear of Campbell bay, several deposits of similar character are found. These have also been opened to some extent but the mineral is generally of the black variety and apparently not of great value. Good sized perfect crystals are rarely found and but little work has, in so far as can be learned, been done at those places.

In the Geology of Canada, 1863, page 35, a dike of pegmatite is recorded as occuring at Montgomery clearing, about five miles west of Pembroke, in which large crystals of brown and black mica occur, but these are said to be rare. Presumably this place has never been well prospected as nothing has been recorded from this locality since that time.

In the vicinity of the Gatineau mica mines have been opened along the post-road about one mile and a half south of the crossing of the Pickanock river with a fair showing of good sized crystals in a mass of pyroxene which cuts the gneiss of the district. This is known as Moore's mine. Farther south a deposit of dark mica was opened several years ago on lot 6, range A., Wright, now the property of the General Electric Co. of Schenectady, N.Y., by Mr. Watters; and on the east side of the river on lot 3, range A., Northfield, several pits have been sunk on pyroxene dikes cutting greyish gneiss, by a Toronto company. Also on lot 13, range B., same township, an opening has been made. With the exception of the Watters property no work has been done at these mines for several years.

Near the line of the Gatineau Valley railway on lot 36, range XII, Low township, in a pegmatite dike which cuts grey gneiss and crystalline limestone, some good crystals of nearly white mica were obtained several years ago in what is known as the Brock mine. This is about half a mile north of Venosta station.

On the east side of the Gatineau in the township of Hincks, lot 22, range II, about two miles from the river, a deposit of dark mica occurring in large crystals was found in connexion with pyroxenic dikes which cut the crystalline limestone. This is known as the Quinn mine. It was operated some years ago by Messrs. Powell and Clemow of Ottawa, by whom nearly two hundred tons of dark mica were extracted and shipped to Ottawa. Work has been suspended at this place for several years.

In the township of Alleyn near Kazabazua river on lot 10, range II, a large deposit of excellent mica has been worked by Mr. Joshua Ellard, of Wright post-office. The country rock is a grey gneiss with limestone, cut by pyroxene dikes, the mica occurring in a band several feet thick, with calcite. The crystals are of good size and quality, amber yellow, and several hundred tons have been extracted.

On lot 12, range I, on land of John Gibson, several openings have been made. The work was carried on by Mr. E. Haycock in 1898, the mica occurring in pyroxene with calcite and was of good quality, some of the crystals being of large size. Not recently worked.

On lot 4, range II, on land ot Mrs. Mullingham, mica occurs in pyroxene with a little apatite and calcite, the enclosing rock being a hard red granite. Some crystals of large size and good quality were obtained. This place was operated at intervals, in 1898–1900, but the amount obtained, though considerable, has not been reported.

In the township of Cawood, on lots 23–24, range III, some good crystals of nearly white mica were found in 1897, and the mine was worked for a short time in the following year by Dr. Duhamel of Hull.

On lot 41, range V, amber mica of good quality was extracted to a small extent in 1898. This locality is said to be about twenty miles north of Shawville on the Pontiac and Pacific railway (C. P. R.). Prospecting has also been carried on to some extent on lots 41 and 43, range IV, and on lots 40, 42, 44, 45, 46, range V.

On lot 12, range VI, is the Prestly mine, the mica occurring in an irregular vein of pyroxene with some calcite, cutting a grey granite. A small amount of work was done here, but the property has apparently been abandoned for the present.

On lot 18, range VI, the Brock and Pritchard mine was worked at intervals in 1898-99. The country rock is largely a reddish granite-gneiss, cut by dikes of pyroxene carrying some calcite. It is situated on the bank of the Kazabazua river, and some large crystals of good quality were obtained, but work has been suspended for several years

Indications of mica are reported from lots 17 and 22, range VII, Low township, and from lot 53, range VIII, Aldfield. Also from lot 14, range I, Clarendon, and from lot 51, range III, Thorne. From the last place several tons were taken.

In the township of Litchfield black mica was found on lots 22–23, range IX, on lot 20, range XI, and in Waltham, on lots 7–8, range A, but the quantity apparently is small in all these localities. The mica from the western areas is for the most part of the black variety.

Asbestus.

The asbestus found in the crystalline rocks of this area is all chrysotile. The principal place where it has been mined is at the Pogan fall near the Gatineau river in the township of Denholm, where operations have been carried on irregularly for more than ten years. The veins are small and the rock is shipped probably for the manufacture of non-conducting cement since the fibre is not sufficiently long for good spinning as compared with that from the Thetford mines.

Small deposits of similar mineral are found near the Pickanock river in the township of Wright, but no attempt at mining has been made at this place. It is also found in serpentinized limestone or pyroxenite near the village of Bryson on the Ottawa river. At none of these places is the quantity sufficient apparently for profitable mining.

Gold.

Attempts to mine gold have been made at a point on the road leading west from Old Pontiac village on the Ottawa at the foot of the Chats falls to Bristol mines. The location is on an irregular body of good looking quartz which is close to the line of the old horse railway past the falls. A shaft was sunk to a depth of about 100 feet, the quartz being followed down for about half this depth when it was apparently cut off by a granite mass. The rocks in the vicinity are schists and limestones cut by red granite. No information as to the gold contents of the quartz is to hand, and work was abandoned in 1899. The rocks belong to the Hastings or Grenville series.

Building Stones.

The limestones of the Trenton, Black River and Chazy formation yield a fine quality of building stone. Large quarries are located at several points, notably on the Black River outcrops south of the entrance of Buckham bay on the Ottawa river in the township of Torbolton; on similar strata to the south of Sand Point; in the Black River

outlier on the south side of the Muskrat river, in the townships of Westmeath and Stafford, and also at Seche point, on the Ottawa, above Coulonge village.

In the crystalline limestones, also, several important quarries are located. Of these that near the village of Portage du Fort has yielded some excellent marble for columns and blocks which have been employed in the Parliament buildings at Ottawa. A very beautiful marble is also found at the village of Bryson. In the township of Ross on lot 19, range VI, a ledge of white crystalline dolomite has been worked to some extent locally and yields a very handsome white stone. The marbles of Arnprior are in similar rocks but here the limestone is variegated with dark bands and cloudings. The rock at Renfrew is somewhat similar and has been worked for building stone and for lime burning for some years.

Some of the massive red granites should furnish an excellent material for constructive purposes. It has not yet been utilized to any extent. A large quarry alongside the line of Gatineau Valley railway, about one mile south of Wakefield station, has been opened in a dark coloured granitic rock for road metal, by the Ottawa city corporation. The rock appears to be well adapted for this purpose.

Molybdenite.

A deposit of this mineral has been worked irregularly for some years at a point about a fourth of a mile south of Healy station on the Canadian Pacific railway. The mineral occurs at the contact of granite with the gneiss, but is in limited quantity. Other small deposits of this mineral are reported as occurring on Calumet island and in the township of Cawood, and in the eastern part of Oldfield, but in so far as yet ascertained the mineral is not in sufficent quantity to be profitably mined, though good specimens can be obtained.

Brick clays.

Brick clays are found at many points throughout the Ottawa basin Brick yards are numerous, and tile works are carried on at several points. One of these is near Kilmaurs post office in Torbolton township, and another near Loch Winnock in the township of McNab. The brick yards are used almost entirely for local demand.

Ochre.

A deposit of ochre is found on lot 7, range III, of Onslow, about one mile west of Quio village. It it owned by Mr. David Ross of that place and has been locally used for some years as a paint. It appears to be quite extensive and of a quality well suited for this purpose.

Shell-Marl.

Deposits of fresh-water marl are found at a number of points in the area south of the Ottawa river. Among the principal of these within the limit of the map-sheet may be mentioned the following.

Mink lake in the township of Wilberforce, about three miles distant from the Eganville branch of the Canadian Pacific railway between Douglas and Eganville. The area of the lake is over 1,000 acres and the marl extends over a large portion of the bottom, showing along the shores, especially on the south side. The depth of the deposit is in places over nine feet, the water is for the most part shallow and the lake can be drained readily by deepening the discharge at the east end.

In the township of Ross several of the lakes which form a long narrow chain extending southeast from Muskrat lake near Cobden into the township of Horton contain marl in their basins. Among the most important of these deposits yet known is that in Green lake on lot 13, range II, where the material is found along the edges with an area of over five acres in one place and a depth of five to twelve feet. Also on the southeast side of the lake over a space of ten acres with about the same thickness.

On a small lake in the vicinity on lot 15, range II, marl is found banked up near the outlet for 200 yards with a depth of four to five feet, and probably underlies the bed of the lake.

In Westmeath marl is reported as occurring in a lake-bottom on lots 9 and 10, east front range B., but the extent of the deposit has not been determined; as also in several small lakes on Calumet island where also the extent is unknown but probably not very large.

APPENDIX

PRELIMINARY LISTS OF ORGANIC REMAINS FROM THE CHAZY, BLACK RIVER, TRENTON, AND PLEISTOCENE FORMATIONS COMPRISED WITHIN THE AREA OF THE PEMBROKE SHEET (No. 122).

BY

HENRY M. AMI, M.A., D.Sc., F.G.S.,

Assistant Palæontologist to the Geological Survey of Canada.

INTRODUCTION.

Of the geological formations which usually characterise the succession of Palæozoic strata in the Ottawa valley, there appear to be represented within the area of the Pembroke sheet, so far as palæontological collections afford evidence, only the Chazy, Black River and Trenton formations. Through the writings of Sir William Logan, J. W. Salter, Alexander Murray, E. Billings, J. F. Whiteaves and others, much work has already been done in describing and illustrating organic remains obtained from within the area of this sheet. There are few localities in Canada where a more interesting collection of palæozoic fossils can be made than at Paquette rapids, on the Ottawa river, near Westmeath P. O. Not only are they well-preserved, but abundant, and consequently they will always prove important to the geologist.

THE CHAZY FORMATION.

The only locality from which collections of Chazy age were obtained within the area of the Pembroke sheet was on Allumette island, and characterized by the presence of *Lingula lyelli*, Billings.

THE BLACK RIVER FORMATION.

The best collections from within the area examined comprise those from the Black River formation. Not only are the remains abundant, but as a rule in such excellent state of preservation that their leading characters may readily be detected, though, at times, the more complete silicification of the hard parts preserved leads to obliteration of some of the characters that ought to be expected. The original collections made by Sir Willian Logan, from the "eastern end of Allumette island" and those made by Messrs. Richardson, Murray, Weston, and the writer, as well as others from Paquette rapids, were no doubt practically from one and the same place. This is *par excellence* one of the finest localities where fossils of Black River age can be obtained to advantage

THE TRENTON FORMATION.

At Eganville rapids there is one outcrop of the Trenton limestone, and several of the localities from which collections were made appear to show outcrops of limestone with fossils approximating the Trenton formation in age. Amongst them are those of the Bonnechère valley,

At top of north slope of hill southwest of Cobden, lot 16, range VI, Bromley township.

Probably lower beds of Trenton or transition.

Receptaculites occidentalis, Salter.
Asaphus (*Isotelus*) *maximus*, Locke,=*A megistos*, (portion of cephalic shield.)
Ceraurus pleurexanthemus, Greene, (cephalic shield.)
Ptilodictya maculata, Ulrich.
Orthis testudinaria, Dalman.
Orthis pectinella, Conrad.
Strophomena incurvata, Shepard.
Rhynchotrema inaequivalvis, Castelnau.
? *Pterinea elliptica*, Hall. (sp.)

Munroe's quarry, lot 19, range 2, Westmeath tp.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Tetradium fibratum, Safford.
Crinoid stems, (fragments)
Strophomena incurvirostra, Shepard.
Camerella panderi, Billings.
Murchisonia bellicincta, Hall.
Murchisonia gracilis, Hall.
Actinoceras bigsbyi, Stokes.
Orthoceras, sp.

Ridge south of Mud creek, lots 12-13, range 11, Stafford township.

Solenopora compacta, Billings, (sp.)
Receptaculites occidentalis, Salter.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments.)
Strophomena incurvata, Shepard.
Rhynchotrema inaequivalvis, Castelnau.
Ctenodonta contracta, ? Salter.
Pleurotomaria progne, Billings.
Pleurotomaria subconica, Hall.
Murchisonia bellicincta, Hall.
Murchisonia gracilis, Hall.
Bellerophon sulcatinus, ? Emmons.
Maclurea logani, Salter.
Orthoceras, sp.
Cyrtoceras falx, Billings.

From quarry near Eganville, lot 18, range VIII, Wilberforce township.

Columnaria halli, Nicholson.
Streptelasma corniculum, Hall.
Crinoid stems, (fragments.)
Asaphus platycephalus, (caudal shield), Stokes.
Monotrypella trentonensis, Nicholson, sp.
Escharopora recta, Hall.
Stictopora acuta, Hall.
Orthis testudinaria, Dalman.
Strophomena incurvata, Shepard.
Plectambonites sericea, Sowerby.
Rhynchotrema inaequivalvis, Castelnau.

From loose specimens near quarry.

Streptelasma corniculum, Hall.
Calapœcia canadensis, Billings.
Batostoma ottawaensis, Foord.
Orthis testudinaria, Dalman.

From boulders on ridge south of Clear lake.

Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Calapœcia canadensis, Billings.
Orthis testudinaria, Dalman.
Maclurea logani, Salter.

SURFACE GEOLOGY.

The surface geology of this district is characterized by the same features as described for the map-sheet adjacent on the east. Great areas of clays, sands and gravels are conspicuous at many points. Some of these show their marine origin by the presence of shells, the remains of fishes, &c., while other large areas apparently on the same horizon are destitute of such organisms.

Clays are well exposed in the eastern portion of the area along the Gatineau Valley railway as far north as Venosta, beyond which the great extent of sand known as the Kazabazua plains comes in, and the clays are largely concealed. In fact a great part of the northern half of the map-sheet shows these sands over many miles from the Gatineau river across the Black and Coulonge rivers and out to the Ottawa at the foot of the Deep river, where they cross and are seen on the south side in the Chalk and Petawawa River plains. These sand plains, broken by occasional rocky ridges, extend south beyond the Bonnechère.

from which Billings listed not less than sixteen species—yet a number of the forms referred to the Trenton, are not uncommonly referred to the Black river also.

Following is a brief historical sketch of the palæontological work already accomplished. This, in turn, is followed by a few lists of such organic remains as have been collected from different localities within the limits of the Pembroke sheet, not previously recorded. Such lists are intended to serve as faunal lists merely.

HISTORICAL SUMMARY.

In his report for 1845-46 Sir William Logan records [1] the following species at the several localities given. I. Romain clearing; Corals, and *Leptaena deltoidea*. II. Pointe Sèche; *Isotelus*, *Calymene*; Univalve and bivalve shells, orthoceratites, encrinites, and corals "replaced by silex." III. Romain point; encrinites, bivalve and univalve shells, &c., as in II and IV Paquette rapids. Many of the species found in II and III, also one *Orthoceras*, "five feet long". V. Allumette falls. *Fucoids*. VI. Head of the Fourth chute of the Bonnechère river; *Isotelus*, *Calymene*, *Orbicula*, *Strophomena*, *Orthis*, *Delthyris*, *Atrypa*, *Nuculites*, *Pleurotomaria*, *Trochus*, *Bellerophon*, *Orthoceras*. VII. Becket island; *Lingula*.

In 1846, Logan [2] points out that marine testacea of the Pleistocene period were found at Pakenham and Fitzroy.

In 1851, Salter [3] identified the following species from the limestones of the "Southeastern end of Allumette island, on the Ottawa river":

Stromatocerium rugosum.
Columnaria alveolata.
Maclurea, sp.
Scalites, n. sp.
Murchisonia ventricosa.
Murchisonia bicincta.
Murchisonia gracilis.
Murchisonia bellicincta.
Turitella-like form.
Euomphalus, more than one form with "smooth shells."
Turbines, or allied shells.
Holopea, one or two species, one closely allied to *H. bilix* of the Western States.

[1] Rep. Progr. Geol. Surv. Can. for 1845-46, pp. 64-67, 1846.
[2] Rep. Progr. Geol. Surv. Can. for 1845-46, p. 71, 1846.
[3] Trans. Sect. Brit. Assoc. Adv. Sc. 1851 (Ipswich meeting) pp. 63-64.

Scalites, three species. (1) a small species, commonly encrusted over ; (2) A muricated form with spines like a *Delphinula* ; (3) *Euomphalus uniangulatus*."

Raphistoma, "two or three species of this genus " which appears to be only a discoid form of *Scalites*.

Turritella (?) A "spirally ribbed " species.

Maclurea, most abundant and characteristic shell.

Ctenodonta, a new genus founded so as to receive two species "resembling *Nucula* in every general character," but which "differed from it importantly by having no internal ligament, but a very manifest exterior one."

Lyrodesma, sp.

Orthis tricenaria, Conrad. Very abundant.

Leptæna filitexta, Hall. Very abundant.

Atrypa increbescens, Hall.

Orthis, two or three species.

Terebratulæ, some small forms.

Bellerophon (*Bucania*) *sulcatina*, Emmons.

Bellerophon, sp., cf. *B. obtectus*, Phillips.

Cleodora. cf. *Atrypa transversa*, Portlock.

Turbo trochleatus.

Turbo tritorquatus, McCoy.

Gonioceras anceps, Hall.

Cyrtoceras annulatum.

Cyrtoceras lamellosum.

Orthoceras arcuoliratum, Hall.

Orthoceras bilineatum, Hall.

Orthoceras laqueatum, Hall.

Ormoceras, sp., "in all probability O. *tenuifilum*, Hall.

Schizocrinus nodosus, Hall.

Streptelasma, one or two species.

Favosites lycoperdon, "branched varities."

Receptaculites "not identical with R. *Neptuni* of Europe.

Asaphus (*Isotelus*) *gigas*, Hall.

In 1852, Logan records[1] phosphatic matters, supposed bones and coprolites found at Lac des Allumettes, in sandstone, associated with remains of *Lingulæ*.

In 1852, Dr. T. Sterry Hunt[2] gives the result of chemical analyses of certain fossil organic remains from Sir William Logan's collections

[1] Proc. Geol. Soc. London, vol. VIII, No. 31, p. 209, Aug. 1, 1852.
[2] Rep. Progr. Geol. Surv. Can. for 1851-52, pp. 109-110. Quebec, 1852.

of 1845 at Lac des Allumettes. *Lingula* and *Pleurotomaria* or *Holopea* occur in coarse siliceous sandstone."

In his report for the year following (1853) Dr. Hunt points out additional results from examination made of the shells referred to in the preceding paragraph.

In 1856, Billings [1] incidentally records the occurrence of *Murchisonia gracilis* from (a) Paquette rapid, (b) the township of Westmeath ; (c) the third chute of the Bonnechère, in the county of Renfrew.

In 1856, Billings [2] records the presence of *Strophomena filitexta* at (1) the Fourth chute of the Bonnechère in the county of Renfrew; (2) the lower end of Allumette island opposite the township of Westmeath in the same county.

In 1856, Billings [3] states that *Oncoeras constrictum*, Hall, is abundant in the lower part of the Trenton limestone at Paquette rapids, in the beds reposing directly upon the Black River limestone.

PLEISTOCENE.

Mr. Billings, [4] under the sub-head "The Lawrencian formation" records *Mallotus villosus*, Cuvier, from the clays of Flat rapids, Madawaska river, county of Renfrew.

In 1857, [5] records five additional species from Paquette rapids, the lower end of Allumette island, the Fourth chute of the Bonnechère river and Fitzroy township as follows:—(1) *Glyptocrinus priscus;* (2) *Cyrtoceras falx*; (3) *C. regulare;* (4) *Orthoceras allumettense:* (5) *O. hastatum.*

In 1857, Murray [6] ascribed the age of the fossiliferous rocks of the southwest corner of the township of Bromley, on the evidence afforded by the organic remains, to the Black River and Trenton formations. No lists are given.

In 1857, Murray [7] cites the occurrence of *Cythere* beyond the dislocation, in the top beds, at the Fourth chute of the Bonnechère. He assigns the age of the strata examined to the different formations from the Calciferous to the Trenton. At the Falls, *orthoceratites* and tur-

[1] Can. Nat. and Geol. Vol. 1. No. 1, chap. IV, p. 42, Ottawa, Feb. 1856.

[2] Can. Nat. and Geol. Vol. 1, No. 111, Chapt. XXXIII, p. 203, June 1856, Montreal, Que.

[3] Can. Nat. and Geol. Vol. 1, No. IV, pp. 312-320, Ottawa, 1856.

[4] Can. Nat. and Geol. Vol. 1, No. V. Chapt. XVII, p. 345, Dec. 1856, Ottawa.

[5] Rep. Progr. Geol. Surv. Can. for 1853-54-55-56, pp. 256-345, Toronto.

[6] Rep. Progr. Geol. Surv. Can. for 1853, p. 96, 1857, Toronto.

[7] Rep. Progr. Geol. Surv. Can. 1853-54--55-56, p. 95, Toronto, 1857.

binate shells, &c., occur in the Chazy, Black River and Trenton formations constituting the first outlier. In the second outlier, *Columnaria alveolata*, *Cythere*, *orthoceratites*, *Atrypa*, *Leptæna*, corals, &c., are recorded. In the third outlier, the *Chazy* formation affords *Scolithus-linearis*, which outlier continues from the foot of Jessup rapids about three miles above the Fourth chute of the Bonnechère to the Eganville rapids, *Leptæna sericea*, *Chætetes lycoperdon* and *Lingula* were abundant with other fossils of the Trenton formation.

In 1858, Billings [1] records the following species of fresh-water shells found forming the shell-marl: *Physaheterostropha*, *Planorbis campanulatus*, *P. bicarinatus*, *Paludina decisa*, *Cyclas orbicularis*, *Unio complanatus*, *Anodonta fluviatilis*.

In 1858, Billings [2] lists the fossils from the Bonnechère valley, as follows:

From the Chazy.
- *Raphistoma staminea*, Hall.
- *Illænus arcturus*, Hall.

From the Birdseye.
- *Murchisonia perangulata*, Hall.

From the Black river.
- *Columnaria alveolata* (Goldfuss).
- *Stromatocerium rugosum* (Hall).
- *Orthoceras multitubulatum* (Hall).
- *Orthoceras tenuifilum* (Hall).

From the Trenton formation.
- *Monticulipora dendrosa* (Billings).
- *Orthis insculpta* (Hall).
- *Orthis tricenaria* (Conrad).
- *Strophomena alternata*, (Conrad).
- *Rhynchonella increbescens*, (Hall).
- *Rhynchonella bisulcata* (Emmons).
- *Pleurotomaria subconica* (Hall).
- *Pleurotomaria umbilicata* (Hall).
- *Murchisonia gracilis* (Hall).
- *Murchisonia bicincta* (Hall).
- *Murchisonia ventricosa* (Hall).
- *Subulites elongatus*, Emmons (Hall).
- *Orthoceras bilineatum* (Hall).

[1] Rep. Progr. Geol. Surv. Can. 1857. p. 149, Toronto, 1858.

[2] Rep. Progr. Geol. Surv. Can. for 1857, pp. 153 and 153, Toronto, 1858.

14. *Phacops callicephalus* (Hall).
15. *Cheirurus pleurexanthemus* (Green).
16. *Acidaspis ? spiniger* (Hall).

Seven additional species are given, but no geological horizon assigned to them, namely :—

1. *Glyptocrinus priscus.* (2) Columns of *Thysanocrinus*, sp. (3) *T. pyriformis.* (4) *Orthis gibbosa ?* (Billings). (5) *Eichwaldia subtrigonalis* (Billings). (6) *Vanuxemia inconstans*, (Billings). (7) *Cyrtodonta canadensis* (Billings).

Then follows a list of seventy-five species found in the beds which hold characteristic Black River fossils "all new forms not known to occur in the Trenton, and all species not clearly identified being excluded."

Tetradium cellulosum ? (Hall).
Columnaria alveolata (Goldfuss), probably *C. Halli*, *Nicholson.*
Monticulipora dendrosa (Billings).
Petraia profunda (Hall).
Petraia corniculum (Hall sp.).
Receptaculites occidentalis (Salter).
Stromatocerium rugosum (Hall).
Glyptocrinus priscus (Billings).
Strophomena alternata (Conrad).
Strophomena filitexta (Hall).
Leptæna sericea (Sowerby).
Orthis testudinaria (Dalman).
Orthis gibbosa (Billings).
Orthis insculpta (Hall).
Orthis tricenaria (Conrad).
Rhynchonella increbescens (Hall).
Rhynchonella recurvirostra (Hall).
Rhynchonella bisulcata (Emmons).
Ctenodonta levata (Hall).
Ctenodonta nasuta (Hall).
Ctenodonta gibbosa (Hall).
Ctenodonta dubia (Hall).
Euomphalus uniangulatus (Hall).

(Note : This is the characteristic species of the Beekmantown ("Calciferous") formation, and is usually designated as *Ophileta compacta*, Salter, or as *Ophileta complanata*, Vanuxem, the three names being synonymous.

Raphistoma staminea (Hall).
Maclurea logani (Salter).
Pleurotomaria lenticularis (Hall).
Pleurotomaria rotuloides (Hall).
Pleurotomaria umbilicata (Hall).
Pleurotomaria subconica (Hall).
Murchisonia bicincta (Hall).
Murchisonia tricarinata (Hall).
Murchisonia ventricosa (Hall).
Murchisonia perangulata, (Hall).
Murchisonia bellicincta, (Hall).
Murchisonia gracilis,(Hall).
Murchisonia subfusiformis, (Hall).
Subulites elongatus, (Emmons).
Bellerophon sulcatinus, (Emmons).
Bellerophon rotundatus, (Hall).
Bellerophon bilobatus, (Sowerby).
Bellerophon expansus, (Hall).
Bellerophon bidorsatus, (Hall).
Bellerophon punctifrons, (Emmons).
Cyrtolites compressus, (Conrad, sp.).
Orthoceras (Ormoceras) tenuifilum, (Hall).
Orthoceras multicameratum, (Emmons).
Orthoceras recticameratum, (Hall).
Orthoceras fusiforme, (Hall).
Orthoceras arcuoliratum, (Hall).
Orthoceras bilineatum, (Hall).
Orthoceras anellum, (Conrad).
Orthoceras amplicameratum, (Hall).
Orthoceras strigatum, (Hall).
Orthoceras laqueatum, (Hall).
Orthoceras allumettense, (Billings).
Orthoceras ottawaënse, (Billings).
Orthoceras hastatum, (Billings).
Orthoceras decrescens, (Billings.
Orthoceras huronense, (Billings).
Gonioceras anceps, (Hall).
Orthoceras subcentrale, (Hall).
Orthoceras longissimum, (Hall).
Orthoceras multitubulatum, (Hall).
Orthoceras annulatum, (Hall).
Oncoceras constrictum, (Hall).

[*Cyrtoceras annulatum*, (Hall).
Cyrtoceras macrostomum, (Hall).
Cyrtoceras multicameratum, (Hall).
Lituites undatus, (Emmons).
Asaphus extans, (Hall).
Illænus arcturus, (Hall).
Ceraurus pleurexanthemus, (Green).
Phacops callicephalus, (Hall).
Illænus ovatus, (Conrad).
Acidaspis ? spiniger, (Hall).

In 1858, Billings [1] published three papers or reports in which he described and illustrated several species from within the area of this sheet. These are as follows :—

A. From Paquette rapids. (1) *Cyrtodonta rugosa*; (2) *C. canadensis*; (3) *C. spinifera*; (4) *C. obtusa*; (5) *C. sub-truncata*, (Hall sp.); (6) *C. subangulata*, (Hall sp.; (7) *Obolus canadensis*; *Eichwaldia subtrigonalis*.

B. From the Fourth chute of the Bonnechère. (1) *Cyrtodonta rugosa*; (2) *C. canadensis*; (3) *C. spinifera*; (4) *C. obtusa*; (5) *C. subtruncata*, (Hall); (6) *Vanuxemia inconstans*; (7) *Obolus canadensis* (8) *Eichwaldia subtrigonalis*.

C. From the township of Stafford, county of Renfrew. (1) *Obolus canadensis*.

D. From the township of Westmeath, county of Renfrew. (1) *Obolus canadensis*.

BONNECHÈRE RIVER VALLEY.

Of Chazy fossils from the Fourth chute of the Bonnechère river, near C. Merrick's mill, where Alex. Murray measured the section published in his report for 1854, pp. 96 and 97, Mr. E. Billings records [2] the following :—

Bryozoa.
Stictopora fenestrata (Hall) or a form closely allied thereto.
Gasteropoda.
Raphistoma staminea (Hall).
Trilobita.
Illænus arcturus (Hall).

[1] Rep. Progr. Geol. Surv. Can. for 1857, Toronto, 1858.
Can. Foss. Descript. N. gen. and sp. Sil. and Dev. Canada, Montreal 1858.
Can. Nat. and Geol. Vol. III, No. 6, Art. XXXIV, pp. 419-443, Montreal, 1858.
[2] Rep. Progr. Geol. Surv. Can. for 1857, pp. 154-155, Montreal, 1858.

In 1858 [1] Salter described and figured a large number of species from Logan's collection.

There are as follows :

Maclurea logani.
Raphistoma lapicida.
Raphistoma aperta.
Helicotoma planulata.
Helicotoma planulata, var *muricata.*
Helicotoma spinosa.
Helicotoma larvata.
Murchisonia bicincta.
Murchisonia serrata.
Murchisonia heiicteres.
Murchisonia (Hormotoma) gracilis, (Hall).
Murchisonia (Hormotoma) ventricosa, (Hall).
Cyclonema halliana.
Cyclonema semicarinata.
Trochonema umbilicata, (Hall).
Eunema strigillata.
Eunema ? pagoda.
Eunema cerithioides.
Loxonema murrayana.
Cyrtoceras falx, (Billings).
Cyrtoceras billingsii.
Ctenodonta nasuta, (Hall).
Ctenodonta logani.
Ctenodonta contracta.
Ctenodonta gibberula.
Ctenodonta astartæformis.
Receptaculites occidentalis.

Besides the above, Salter records other forms from the same collection, as follows :—

Bellerophon sulcatinus, B. rotundatus, Stromatoceruum rugosum, Columnaria alveolata, Gonioceras anceps, Strophomena filitexta, Pentamerus (Atrypa) hemiplicatus, Atrypa increbescens, Cyrtoceras annulatum, C. lamellosum, Orthoceras arcuoliratum, O. bilineatum, O. laqueatum, Ormoceras tenuifilum, Schizocrinus nodosus, Petraia (Streptelasma), sp., *Favosites lycoperdon, Asaphus gigas, Murchisonia (Loxonema) sub-*

[1] Dec. 1. Figs. and descript. Can. Org. Rem., Geol. Surv. Can. 1858.

fusiformis, *Lyrodesma*, *n. sp.*, *Strophomena planumbona*, *Holopea obliqua*, *and Glyptocystites*, *sp.*

In 1858, Prof. T. Rupert Jones, F.R.S. [1] describes, records and illustrates the following Ostracoda from Paquette rapids :—(1) *Leperditia canadensis*, Jones, var. *Paquettiana*, n. var. (2) *Cytheropsis concinna*, Jones. (3) *C. siliqua*, Jones. (4) *C. rugosa*, Jones.

In 1859, Billings [2] records describes and figures *Lingula lyelli* from the Calciferous sandrock of Allumette island, but later, [3] in discussing fossils from the Chazy limestones removes this species from the Calciferous sandrock and places it in the Chazy formation, and besides *Lingula lyelli*, records also *Strophomena incrassata*, Hall, from the Fourth chute of the Bonnechère, and *Orthoceras allumettense* from Paquette rapids, and *Bathyurus angelini* is recorded from the Chazy limestone of Fitzroy Harbour.

In 1860, Billings [4] described and figured the following species, all from Paquette rapids. (1) *Straparollus circe*, (2) *S. Eurydice* ; (3) *S. asperostriatus* ; (4) *Bellerophon argo* ; (5) *B. Charon* ; (6) *Phragmoceras primævum* ; (7) *Orthoceras tener* ; (8) *O. pertinax*.

From 1861-1865, Billings [5] described, and figured a number of species from within the area of the Pembroke sheet, as follows :—

(1) *Holopea pyrene* ; (2) *H. nereis* ; (3) *Pleurotomaria arachne* ; (4) *Murchisonia procris* ; (5) *Eunema cerithioides* ; (6) *Subulites parvulus* ; (7) *Metoptoma erato* ; (8) *Conocardium immaturum* ; (9) *Modiolopsis nais* ; (10) *Ctenodonta abrupta* ; (11) *Cyrtodonta leucothea* ; (12) *Petraia aperta* ; (13) *Porambonites ottawaënsis* ; (14) *Pleurotomaria dryope* ; (15) *P. Vitruvia* ; (16) *Murchisonia alexandra* : (17) *Metoptoma superba* ; (18) *Cyrtocerina typica* ; (19) *Chiton canadensis*.

In his admirable compendium of the geology of Upper and Lower Canada, Sir W. E. Logan, [6] records with Mr. E. Billings the following species at Allumette rapids :—(1) *Lingula lyelli* ; (2) *Pleurotomaria* or *Holopea* ; and ascribes them to the Chazy formation.

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[1] Figs. and Descrip. Can. Org. Rem. Dec. 3. Montreal, 1858.

[2] Can. Nat. and Geol. Vol. IV. No. 5. Art. XXVIII, p. 348, Montreal, 1859.

[3] 2 ibid. Art. XXIV, No. 6. Dec. 1859, p. 426, Montreal, 1859.

[4] Can. Nat. and Geol. Vol. V, No. 3, June, 1860. Montreal.

[5] Palæozoic Fossils, Vol. 1, 1861-1860, Montreal.

[6] "Geology of Canada" 1863. p. 125, Montreal.

In 1883,[1] Arthur H. Foord, F.G.S., records two species of organic remains from the strata of Paquette rapids, Ottawa river, as follows :—

Monotrypella aequalis, Ulrich, p. 15.
1882. Ulrich, E.O., Journ. Cincinnati Soc. Nat. Hist., Vol. V, p. 247, pl. 2, figs. 3, 3a, 3b, 1882.

Locality, formation and collector :—Paquette rapids on the Ottawa river ; Black River formation ; James Richardson.

Batostoma Ottawaënse, Foord. p. 18, pl. 2, figs. 1-1f.

Locality, formation and collector :—Paquette rapids ; James Richardson ; Black River.

In 1888, Dr. Arthur H. Foord, F.G.S., formerly Assistant-Palæontologist to the Geological Survey of Canada, recorded[2] the occurrence of Canadian species of Cephalopoda in the collections of the British Museum. These are as follows :—

Orthoceras arcuoliratum, Hall.
Cyrtoceras falx, Billings.

Both species are stated to have come from Allumette island, Ottawa river, Canada.

In 1896, the writer presented a paper to[3] the Royal Society of Canada bearing on the faunas characterizing the geological formations and outliers of the Ottawa Palæozoic Basin. This paper was intended as an appendix or supplement to one presented by Dr. R.W. Ells before the same society, entitled :—" Palæozoic outliers in the Ottawa basin."

The writer listed some sixty-two of the most characteristic species of fossils from the Black River formation of Paquette rapids, from within the area comprised in the Pembroke sheet.

The sixty-two species therein listed were all taken from the collections made by officers of the Geological Survey of Canada, and their generic as well as specific designations were given in so far as more recent changes in nomenclature and classification seemed to warrant. They included the following :—

[1] Contrib. Micro—Palæontology of the Cambro-Silurian rocks of Canada, Geol. and Nat. Hist. Surv. of Canada, Ottawa, 1883.

[2] Catal. Fossil Cephalopoda, British Museum, Vol. 1, Pt. 1, p. 10, London, 1888.

[3] "Notes on some of the Fossil Organic Remains comprised in the Geological formations and outliers of the Ottawa Palæozoic Basin" Trans. Roy. Soc. Can. Vol. II. New Series) Sect. IV, pp. 151-158, 1896.

PAQUETTE RAPIDS FOSSILS, ALLUMETTE ISLAND OUTLIER.

Receptaculites occidentalis, Salter.
Stromatocerium rugosum, Hall.
Tetradium fibratum, Safford.
Calapœcia canadensis, Billings.
Columnaria halli, Nicholson.
Streptelasma profundum, Hall.
Petraia aperta, Billings.
Orthis (Porambonites) ottawaënsis, Billings.
Solenopora compacta, v. *Paquettiana*, Ami.
Eichwaldia subtrigonalis, Billings.
Camarella volborthi, Billings.
Camarella panderi, Billings.
Dinobolus magnificus, Billings.
Modiolopsis nais, Billings.
Ctenodonta astartæformis, Billings.
Ctenodonta gibberula, Salter.
Ctenodonta logani, Salter.
Conocardium immaturum, Billings.
Cyrtodonta spinifera, Billings.
Cyrtodonta leucothea, Billings.
Loxonema murrayanum, Salter.
Straparollina asperostriata, Billings.
Straparollina circe, Billings.
Straparollina eurydice, Billings.
Holopea nereis, Billings.
Holopea pyrene, Billings.
Cyclonema hallianum, Salter.
Eunema cerithioides, Salter.
Eunema strigillatum, Salter.
Eotomaria pagoda, Salter.
Eotomaria dryope, Billings.
Helicotoma planulata, Salter.
Helicotoma larvata, Salter.
Raphistoma lapicidum, Salter.
Raphistoma apertum, Salter.
Liospira vitruvia, Billings.
Plethospira ? arachne, Billings.
Omospira alexandra, Billings.
Lophospira helicteres,, Salter.
Lophospira perangulata, Hall.
Lophospira serrulata, Salter.

Chiton canadensis, Billings.
Metoptoma erato, Billings.
Scenella superba, Billings.
Bellerophon charon, Billings.
Oxydiscus argo, Billings.
Maclurea logani, Salter.
Actinoceras allumettense, Billings.
Actinoceras bigsbyi, Bronn.
Orthoceras bilineatum, Hall.
Orthoceras laqueatum, Hall.
Orthoceras strigatum, Hall.
Orthoceras arcuoliratum, Hall.
Orthoceras hastatum, Billings.
Orthoceras tenerum, Billings.
Oncoceras constrictum, Hall.
Cyrtoceras billingsi, Salter.
Cyrtoceras falx, Billings.
Cyrtoceras regulare, Billings.
Cyrtocerina typica, Billings.
Gonioceras anceps, Hall.
Cytheropsis siliqua, Jones.
Leperditia canadensis, v. *Paquettiana*, Jones.

In 1897, Prof. E. O. Ulrich [1] described the Lower Silurian Lamellibranchiata, Ostracoda and Gasteropoda of Minnesota. In the course of his remarks on the various genera and species characterizing those strata which are contemporaneous or homotaxial with those of the Ottawa Palæozoic basin, and of the area of the Pembroke sheet in particular, he mentions several species from Paquette rapids and Allumette island, giving descriptions of two new species and one new variety from within the area in question. The following are the species from Paquette rapids :—

Ctenodonta nasuta, (N. var.)
Oxydiscus argo, Billings, sp.
Scenella superba, Billings, sp.
Raphistoma lapicida, Salter.
Omospira alexandra, Billings.
Lophospira serrulata, Salter.
Lophospira helicteres, Salter.
Lophospira perangulata, Hall.
Liospira (?) mundula, Ulrich. (N. sp.)

[1] The Geol. of Minnesota, Vol. III, Final Report, Palæontology, Minneapolis, 1897.

Hormotoma salteri, Ulrich, (N. sp.)
Solenospira pagoda, Salter, sp.
Helicotoma planulata, Salter.
Gyronema semicarinatum, Salter, sp.

Dr. Whiteaves [1] describes and records for the first time from the Black River limestone of Paquette rapids, *Nanno aulema*, Clarke.

In 1900, Lambe, [2] records the species *Tetradium fibratum*, Safford, from Paquette rapids; and in the following year [3] the same author discusses the following corals from Paquette rapids: *Columnaria halli*, Nicholson, *Petraia profunda*, Hall, *P. aperta*, Billings, and *Streptelasma corniculum*, Hall.

Determinations of fossils from Paquette rapids, Ottawa river, collected by Mr. Weston, of the Geological Survey of Canada.

In the years 1872 and 1880, Mr. T. C. Weston, F.G.S.A., then a member of the Geological Survey staff, visited Paquette rapids, Ottawa river, and his excellent collections contain the following species determined by the writer.

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[1] Ottawa Naturalist, Vol. XII, No. 6, p. 116, Sept. 1898, Ottawa.
[2] Contrib. Can. Pal. Vol. IV. pt. I. p. 93. Ottawa, 1899-1900.
[3] 2. ibid, Pt. 11. Ottawa, 1901.

Genera and Species.	Author.	1872.	1880.
PROTOZOA.			
Receptaculites occidentalis	Salter.	*	*
HYDROZOA.			
Stromatocerium rugosum	Hall.	*	*
ZOOPHYTA.			
Columnaria halli	Nicholson	.....	*
Streptelasma profundum	Hall.	.....	*
Petraia aperta	Billings	*	.....
Tabulate coral indt	.....	*	.....
CRINOIDEA.			
Crinoidal fragments	.....	*	.....
MONTICULIPOROIDEA.			
Branching forms of *Monticulip roidea.* indt.	.....	*	*
BRACHIOPODA.			
Orthis tricenaria	Conrad	*	.....
Dalmanella testudinaria	Dalman	*	*
Strophomena incurvata	Shepard	.....	*
GASTEROPODA.			
Oxydiscus argo	Billings	*	.....
Bellerophon charon	Billings	.....	*
Bellerophon, sp.	.....	.....	*
Eunema? pagoda	Salter	*	.....
Eunema cerithioides	Salter	.....	*
Eunema strigillatum	Salter	.....	*
Helicotoma larvata	Salter	*	.....
Murchisonia, sp.	.....	*	.....
Maclurea logani	Salter	*	*
PELECYPODA.			
Ctenodonta gibberula	Salter	.....	*
Ctenodonta contracta	Salter	*	.....
Ctenodonta astartæformis	Salter	.....	*
Ctenodonta nasuta	(Conrad)	*	.....
Ctenodonta logani	Salter	*	.....
CEPHALOPODA.			
Orthoceras recticameratum	Hall	*	.....
Orthoceras, sp., cf. O. *vulgatum*	Billings	.....	*
Actinoceras bigsbyi	Bronn	*	.....
Cyrtoceras, sp., cf. *C. falx*	Billings	*	.....

Determinations of fossils from localities within the area of the Pembroke sheet, collected by Dr. R. W. Ells.

COLLECTION A. Outcrop No. 1, Boom point, western extremity of Pointe Sèche bay, township of Mansfield, county of Pontiac, Quebec, Collector : R. W. Ells, 1899.

LIST OF SPECIES.

Stromatocerium rugosum, Hall.

Calapœcia canadensis, Billings.

Columnaria halli, Nicholson.

Obscure tabulate coral, genus and species as yet undetermined.

Monticuliporoidea, several species requiring micro-sections before they can be identified.

Strophomena, sp.

Orthis tricenaria, Conrad.

Cyrtodonta, sp. too imperfectly preserved to be identified.

? ? *Operculum* of gasteropod, like that of a *Maclurea*.

Asaphus, sp. fragments of the cephalon.

Cheirurus sp. a form related to *Cheirurus pleuraxanthemus*, Green.

HORIZON.

The association of species in the above collection appears to indicate an horizon near the summit of the Black River formation, of Ordovician age.

COLLECTION B. Outcrop No. 2, Pointe Sèche; lower or eastern extremity of Pointe Sèche bay, township of Mansfield, county of Pontiac, Que. Collector, R. W. Ells, 1899.

LIST OF SPECIES.

Receptaculites occidentalis, Salter.

Streptelasma profundum, Hall.

Solenopora compacta, Billings.

Pachydictya, sp.

Intricaria reticulata, Hall. (—*Subretepora reticulata*.)

Batostoma ottawaënse, Foord, or a closely related form.

Monticuliporoidea, several species requiring micro-sections before they can be identified.

Crania ? sp.,

Strophomnena incurvata, Shepard. (*Streptorhynchus filitextum* of authors.)

Rafinesquina alternata (Emmons) Conrad.

Orthis (*Dalmanella*) *testudinaria*, Dalman.

Rhynchotrema inæquivalvis, Castelnau. (—*Rhynchonella increbescens* of authors.)

Hyolithes, sp., too imperfect for identification.

Euomphalus ? sp. indt.

Murchisonia (Hormotoma) sp., a form resembling *Murchisonia alexandra*, Billings.

Maclurea, sp. too imperfect for identification.

Orthoceras sp. Only the body chamber of a species of Orthoceratite is preserved and therefore the specimen is too imperfect for specific determination.

Orthoceras, sp., related to O. *hastatum*, Billings.

Bathyurus, sp. allied to B. *extans*, Hall.

Asaphus megistos, Locke, or a very closely related form.

Illœnus sp. cf. *Illœnus Americanus*, Billings.

Lichas trentonensis, Hall.

Primitia logani, Jones,

Leperditia canadensis, Jones.

HORIZON, &c.

The fossils are preserved in a yellowish-grey weathering, impure, partly crystalline limestone holding crinoidal fragments.

The fauna represented in the foregoing list indicates the presence of strata which can be more properly referred to the upper half of the *Black River formation;* The presence of *Receptaculites occidentalis*, Salter, and *Streptelasma profundum*, Hall, evidently point in that direction. There are a number of forms, including *Rhynchotrema inæquivalvis*, *Dalmanella testudinaria*, *Lichas trentonensis*, and rolled or worn specimens of *Solenopora compacta* which appear to indicate the lower beds of the Trenton formation.

COLLECTION C. Loose blocks of limestone, shores of Pointe Sèche bay, township of Mansfield, county of Pontiac, Quebec.
Collector: R. W. Ells. 1899.

Crinoidal fragments.

Bryozoa, several genera and species which require microsections before they can be identified. *Pachydictya*, *Ptilodictya*, *Stictopora* appear to be present.

Monticuliporoidæ, several branching forms which require micro-sections also before they can be accurately determined.

Strophomena, sp. a fragment, too imperfectly preserved to be identified.

Rhynchotrema inæquivalvis, Castelnau.

Camarella panderi, Billings. A well preserved and adult form of this rather rare species.

Bellerophon ? ? sp.,

Lophospira perangulata, Hall.

Obscure gasteropod, probably a species of *Murchisonia*.

Asaphus, sp. fragment of the head shield, too imperfect to be determined specifically.

HORIZON, &c.

The above association of species indicates that the blocks of limestone are probably of Black River or Lower Trenton age.

PAQUETTE RAPIDS, OTTAWA RIVER, COLLECTOR: JOHN STEWART. 1887.

Amongst the collections examined by the writer from various localities within the area of the Pembroke sheet, there occurs one, made by Mr. John Stewart, formerly of the Interior Department, Ottawa. It was made in 1887 at the type locality and contains the following species :—

Palæophyllum, sp. cf. P. *rugosum*. Nicholson.

Columnaria, sp. cf. C. *incerta*, Billings. or undescribed form.

Cyclonema or *Lophospira*, too imperfect for identification.

Holopea nereis, Billings.

Eunema pagoda, Salter. (*Solenospira pagoda*, Salter sp.)

Pleurotomaria dryope, Billings.

MUSEUM OF THE GEOLOGICAL SURVEY DEPARTMENT, OTTAWA.

In the Museum cases of the Geological Survey Department at Ottawa there are exhibited a large number of species of fossils which serve to illustrate the palæontological materials which characterize the rock formations of the area comprised in the Pembroke sheet (No. 122). Of these there are those from Paquette rapids, and from the Bonnechère river, which form important series, as follows:—

A.

FROM PAQUETTE RAPIDS, OTTAWA RIVER.

LIST OF SPECIES.

PROTISTA.

Receptaculites occidentalis, Salter.

HYDROZOA.

Stromatocerium rugosum, Hall.

ZOOPHYTA.

Tetradium fibratum, Safford.
Calapœcia canadensis, Billings.
Columnaria halli, Nicholson.
Petraia aperta, Billings.
Streptelasma profundum, Hall.
Streptelasma corniculum, Hall.
Pachydictya acuta, Hall.

BRACHIOPODA.

Obolellina magnifica, Billings.
Strophomena incurvata, Shepard.
Dalmanella testudinaria, Dalman.
Porambonites ottawaënsis, Billings.
Rhynchotrema inæquivalvis, Castelnau. (*Rhynchonella increbescens*, Hall.
Camarella volborthi, Billings.
Eichwaldia subtrigonalis, Billings.
Camarella panderi, Billings.

PELECYPODA.

Lyrodesma poststriatum, Emmons.
Modiolopsis nais, Billings.
Modiolopsis faba, Conrad.
Modiolopsis carinata, Hall.
Ctenodonta abrupta, Billings.
Ctenodonta astartæformis, Salter.
Ctenodonta contracta, Salter.
Ctenodonta gibberula, Salter.
Ctenodonta nasuta, Conrad.
Ctenodonta logani, Salter.
Cyrtodonta canadensis, Billings.
Cyrtodonta spinifera, Billings.
Cyrtodonta rugosa, Billings.
Cyrtodonta obtusa, Hall.
Cyrtodonta leucothea, Billings.
Conocardium immaturum, Billings.

GASTEROPODA.

Loxonema murrayanum, Salter.
Straparollina asperostriata, Billings.
Straparollina circe, Billings.

Straparollina eurydice, Billings.
Holopea nereis, Billings.
Holopea pyrene, Billings.
Cyclonema hallianum, Salter.
Cyclonema semicarinatum, Salter.
Trochonema umbilicatum, Hall.
Eunema cerithiodes, Salter.
Eunema strigillatum, Salter.
Eunema pagoda, Salter.
Helicotoma planulata, Salter.
Helicotoma spinosa, Salter.
Helicotoma larvata, Salter.
Raphistoma lapicidum, Salter.
Raphistoma apertum, Salter.
Pleurotomaria vitruvia, Blllings.
Pleurotomaria dryope, Billings.
Pleurotomaria arachne, Billings.
Murchisonia procris, Billings.
Murchisonia alexandra, Billings.
Murchisonia bellicincta, Hall.
Murchisonia gracilis, Hall.
Murchisonia perangulata, Hall.
Murchisonia milleri, Hall.
Murchisonia helicteres, Salter.
Murchisonia serrulata, Salter.
Murchisonia ventricosa, Hall.
Chiton canadensis, Billings.
Metoptoma erato, Billings.
Metoptoma superba, Billings.
Bellerophon charon, Billings.
Bellerophon argo, Billings.
Bellerophon bilobatus, Sowerby.
Bucania bidorsata, Emmons.
Cyrtolites compressus, Conrad.
Pterotheca expansa, Hall.
Maclurea logani, Salter.

CEPHALOPODA.

Orthoceras (Actinoceras) allumettense, Billings.
Orthoceras (Actinoceras) bigsbyi, Stokes.
Orthoceras bilineatum, Hall.
Orthoceras laqueatum, Hall.

Orthoceras anellum, Conrad.
Orthoceras strigatum, Hall.
Orthoceras arcuoliratum, Hall.
Orthoceras hastatum, Billings.
Orthoceras recticameratum, Hall.
Orthoceras tenerum, Billings.
Endoceras multitubulatum, Hall.
Oncoceras constrictum, Hall.
Cyrtoceras billingsi, Salter.
Cyrtoceras falx, Billings.
Cyrtoceras regulare, Billings.
Gonioceras anceps, Hall.

TRILOBITA.

Dalmanites callicephalus, Green.
Cytheropsis siliqua, Jones.
Cytheropsis rugosa, Jones.
Leperditia canadensis, Jones.

B.

FROM BONNECHÈRE RIVER, COUNTY OF RENFREW, ONTARIO. FOURTH CHUTE OF THE BONNECHÈRE RIVER, COLLECTED BY E. BILLINGS.

Pachydictya acuta, Hall.
Obolellina canadensis, Billings.
Orthis (Hebertella) insculpta, Hall.
Strophomena incurvata, Shepard.
Cyrtodonta canadensis, Billings.
Bathyurus spiniger, Hall.

These two series, A and B are to be seen in the Black River cases of the Geological Museum on Sussex street, Ottawa.

Peter Redpath Museum Collections. McGill University, Montreal.

A.—PAQUETTE RAPIDS, OTTAWA RIVER.

List of species of Organic remains from Paquette rapids, Ottawa river, exhibited in the cases of the Peter Redpath Museum of McGill University, Montreal.

These were determined for the most part by the late Sir William Dawson and various officers of the Geological Survey of Canada. They include specimens from the "Dawson Collection" and were collected by Mr. R. J. B. Howard, B. A., and the writer in 1878 and 1880 respectively. They are all referred to the Black River division of the Trenton group, and although the most recent and more critical nomen-

clature is not employed in the generic as well as specific references, nevertheless, the species and fauna can easily be recognised.

The numbers are those noted on the specimens in the Peter Redpath Museum. The name of the collector, the precise locality and the date when the specimens were collected, whenever obtainable or indicated, have been added.

PAQUETTE RAPIDS FOSSILS, OTTAWA RIVER.

Stromatocerium rugosum, Hall. Nos. 752 and 862. H. M. A. 1880.

Receptaculites occidentalis, Salter. No. 764, H. M. A. 1880.

Calapœcia canadensis, Billings, No. 757, Donor: Geological Survey.

Columnaria alveolata. (=*Columnaria halli*, Nicholson,) No. 1867. Dr. D. K. Cowley.

Petraia cornicula, Hall. No. 741.

Petraia profunda, (=*Streptelasma profundum*, Hall) No. 742. R. J. B. Howard, 1879.

Orthis tricenaria, Conrad, No. 709, R. J. B. Howard, Esq. 1879.

Strophomena, sp. (A slab of limestone with several specimens of *Strophomena incurvata*, Shepard, the *Streptorhynchus filitextusum*, of Hall, and authors generally). No. 968. Also *Murchisonia bellicincta* on the same slab.

Bellerophon charon, Billings. H. M. A. 1880.

Helicotoma planulata, Salter, H. M. A. 1880.

There is a specimen labelled *Helicotoma larvata*, which is evidently *H. planulata*, Salter, No. 694, R. J. B. Howard, Esq., 1879.

Murchisonia gracilis, Hall, No. 660, R. J. B. Howard, Esq., 1879.

(Another specimen, No. 667 is silicified and was collected by the same person, same date.)

Murchisonia bicincta, Hall. (=*Murchisonia milleri*, Hall); (=probably *Hormotoma bicincta*, Hall) No. 6, 62, Donor: Geological Survey.

Murchisonia bellicincta, Hall. No. 681, Two specimens: One silicified, the other not, the latter is a dolomitized cast of the interior of a specimen.

Ctenodonta gibbosa, Salter, H. M. A. 1880. *Ctenodonta nasuta*, Conrad. No. 690, J. Richardson,

Ctenodonta nasuta, Conrad, H. M. A. 1880.

Ctenodonta astartæformis, Salter, H. M. A. 1880.

Maclurea logani, Salter. (a) No. 674, *Opercula*, No. 675. Examples of shells in a silicified condition. R. J. B. Howard, 1879, (b) Nos. 929, 930, 931, 932, These include several silicified shells and opercula of this interesting species, H. M. A. Sept. 1880.

? *Lituites undatus*, H. M. A. 1880.

Orthoceras bigsbyi, No. 654. Silicified example exhibiting portion of the mummuloidal siphuncle with fifteen annulations.

Orthoceras, sp., E. Billings.

(B) JESSUP RAPIDS, OTTAWA RIVER.

From the above locality there are three species exhibited in the Museum cases of McGill University as follows:—

Columnaria alveolata, (=*Columnaria halli*, Nicholson,) No 892.

Orthoceras pretiosa (sic) No. 874. This orthoceratite appears to be an *Endoceras*, allied to *Endoceras proteiforme*, Hall, Donor: Geological Survey.

Endoceras; No. 813, Collector and date not given.

(C) POINTE SÈCHE, FORT COULONGE.

Stromatocerium rugosum, Hall.

A silicified example of this species. Colloctor: J. Richardson.

(D) FOURTH CHUTE OF THE BONNECHÈRE.

Murchisonia gracilis, Hall. A silicified specimen. Collector's name not indicated.

THE PLEISTOCENE DEPOSITS.

(A) THE MARINE SEDIMENTS. LEDA CLAY OR "GREENS CREEK FORMATION."

Mallotus villosus, Cuvier, The ordinary capelin of the lower St. Lawrence and Hudson Bay locality:—Flat rapids, Madawaska river, Renfrew county, O.

(B) THE FRESH-WATER MARL DEPOSITS: LACUSTRINE.

Anodonta fluviatilis.
Cyclas orbicularis.
Paludina decisa.
Physa heterostropha.
Planorbis campanulatus.

SELECTED LIST OF REPORTS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE MINES DEPARTMENT OF CANADA

(A.—*Published by the Geological Survey.*)

MINERAL RESOURCES BULLETINS

818. Platinum.
851. Coal.
854. Asbestus.
857. Infusorial Earth.
858. Manganese.
859. Salt.
860. Zinc.
869. Mica.
872. Molybdenum and Tungsten.
877. Graphite.
880. Peat.
881. Phosphates.
882. Copper.
913. Mineral Pigments.
953. Barytes.

---

745. Altitudes of Canada, by J. White. 1899. (40c.)

BRITISH COLUMBIA.

212. The Rocky Mountains (between latitudes 49° and 51° 30'), by G. M. Dawson. 1885. (25c.).
235. Vancouver Island, by G. M. Dawson. 1886. (25c.).
236. The Rocky Mountains, Geological Structure, by R. G. McConnell. 1886. (20c.).
263. Cariboo mining district, by A. Bowman. 1887. (25c.).
272. Mineral Wealth, by G. M. Dawson.
294. West Kootenay district, by G. M. Dawson. 1888–89. (35c.).
573. Kamloops district, by G. M. Dawson. 1894. (35c.)
574. Finlay and Omineca Rivers, by R. G. McConnell. 1894. (15c.)
743. Atlin Lake mining div., by J. C. Gwillim. 1899. (10c.)
939. Rossland district, B.C., by R. W. Brock. (10c.)
940. Graham Island, B.C., by R. W. Ells, 1905. (10c.)
949. Cascade Coal Field, by D. B. Dowling. (10c.)

YUKON AND MACKENZIE.

260. Yukon district, by G. M. Dawson. 1887. (30c.)
295. Yukon and Mackenzie Basins, by R. G. McConnell. 1889. (25c.)
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. (10c.)
884. Klondike gold fields, by R. G. McConnell. 1901. (25c.)
725. Great Bear Lake and region, by J. M. Bell. 1900. (10c.)
908. Windy Arm, Tagish Lake, by R. G. McConnell. 1906. (10c.)
942. Peel and Wind Rivers, by Chas. Camsell.
943. Upper Stewart River, by J. Keele. } Bound together. (10c.)
979. Klondike gravels, by R. G. McConnell. }

ALBERTA.

237. Central portion, by J. B. Tyrrell. 1886. (25c.)
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-91. (25c.)
703. Yellowhead Pass route, by J. McEvoy. 1898. (15c.)

SASKATCHEWAN.

213. Cypress Hills and Wood Mountain, by R. G. McConnell. 1885. (25c.)
601. Country between Athabaska Lake and Churchill River, by J. B. Tyrrell and D. B. Dowling. 1895. (15c.)
868. Souris River coal-field, by D. B. Dowling. 1902. (10c.)

MANITOBA.

264. Duck and Riding Mountains, by J. B. Tyrrell. 1887–8. (10c.)
296. Glacial Lake Agassiz, by W. Upham. 1889. (25c.)
325. Northwestern portion, by J. B. Tyrrell, 1890–91. (25c.)
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. } Bound together.
705. " (east shore), by J. B. Tyrrell. 1898. (25c.) } Bound together.

KEEWATIN AND FRANKLIN.

217. Hudson Bay and strait, by R. Bell. 1885. (15c.)
238. Hudson Bay, south of, by A. P. Low. 1886. (10c.)
239. Attawapiskat and Albany Rivers, by R. Bell. 1886. (15c.)
244. Northern portion of the Dominion, by G. M. Dawson. 1886. (20c.)
578. Berens River Basin, by D. B. Dowling. 1894. (15c.)
618. Northern Keewatin, by J. B. Tyrrell. 1896. (30c.).
787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900. (25c.)
815. Ekwan River and Sutton Lakes. by D. B. Dowling. 1901. (15c.)
905. The Cruise of the *Neptune*, by A. P. Low. 1905. ($2.00).

ONTARIO.

215. Lake of the Woods region, by A. C. Lawson. 1885. (25c.)
265. Rainy Lake region, by A. C. Lawson. 1887. (25c.)
266. Lake Superior, mines and mining, by E. D. Ingall. 1888. (25c.)
326. Sudbury mining district, by R. Bell. 1890-91. (20c.)
327. Hunter island, by W. H. Smith. 1890-91. (20c.)
332. Natural Gas and Petroleum, by H. P. H. Brumell. 1890-91. (25c.)
357. Victoria, Peterborough and Hastings counties, by F. D. Adams. 1892-93. (10c.)
627. On the French River sheet, by R. Bell. 1896. (10c.)
678. Seine River and Lake Shebandowan map-sheets, by W. McInnes. 1897. (20c.)
672. Nipissing and Timiskaming map-sheets, by A. E. Barlow. 1896. (In Vol. X. 80c.)
723. Iron deposits along Kingston and Pembroke Ry., by E. D. Ingall. 1900. (25c.)
739. Carleton, Russell and Prescott counties, by R. W. Ells. 1899 (25c.)(See No. 739 Quebec).
741. Ottawa and vicinity, by R. W. Ells. 1900. (15c.)
790. Perth sheet, by R. W. Ells. 1900. (10c.)
873. Sudbury Nickel and Copper deposits, by A. E. Barlow. (In Vol. XIV. 80c.)
977. Report on Pembroke sheet, Ont., by R. W. Ells. (10c.)
961. Reprint of No. 873.
962. " " 672.

QUEBEC.

216. Mistassini expedition, by A. P. Low. 1884-5. (10c.)
240. Compton, Stanstead, Beauce, Richmond and Wolfe counties, by R. W. Ells. 1886. (25c.)
268. Mégantic, Beauce, Dorchester, Lévis, Bellechasse and Montmagny counties, by R. W. Ells. 1887-8. (25c.)
297. Mineral resources, by R. W. Ells. 1889. (25c.)
328. Portneuf, Quebec and Montmagny counties, by A. P. Low. 1890-91. (15c.)
579. Eastern townships, Montreal sheet, by R. W. Ells and F. D. Adams. 1894. (15c).
670. Auriferous deposits, Southeastern portion, by R. Chalmers. 1895. (20c.)
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. (15c.)
672. Timiskaming map-sheet, by A. E. Barlow. 1896. (30c.) (In Vol. 10. 80c.)
707. Eastern townships, Three Rivers sheet, by R. W. Ells. 1898. (20c.)
739. Argenteuil, Wright, Labelle and Pontiac counties, by R. W. Ells. 1899. (25c.) (See No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. (15c.)
863. Wells on Island of Montreal, by F. D. Adams. 1901. (30c.)
923. Chibougamou region, by A. P. Low. 1905. (10c.)

UNGAVA AND LABRADOR.

217. Hudson Strait and Bay, by R. Bell. 1885. (15c.)
267. James Bay and east of Hudson Bay, by A. P. Low. 1887-88. (25c.)
584. Labrador Peninsula, by A. P. Low. 1895. (30c.)
657. Richmond Gulf to Ungava Bay, by A. P. Low. 1896. (10c.)
680. Hudson Strait (south shore) and Ungava Bay, by A. P. Low. 1898. (15c.) } Bound together.
713. Hudson Strait (north shore), by R. Bell. 1898. (20c.) } Bound together.
778. Hudson Bay, east coast, by A. P. Low. 1901. (25c.)
819. Nastapoka Islands, Hudson Bay, by A. P. Low. 1901. (10c.)

NEW BRUNSWICK AND NOVA SCOTIA.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. (20c.)
219. Carleton and Victoria cos., by L. W. Bailey. 1885. (20c.)
242. Victoria, Restigouche and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. (10c.)
243. Guysborough, Antigonish, Pictou, Colchester and Halifax counties, N.S., by Hugh Fletcher and E. R. Faribault. 1886. (25c.)
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-88. (25c.)
330. Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890-91. (10c.)
331. Pictou and Colchester counties, N.S., by H. Fletcher. 1890-91. (20c.)
358. Southwestern Nova Scotia (Preliminary), by L. W. Bailey. 1892-93. (10c.)
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. (20c.)
661. Mineral resources, N.B., by L. W. Bailey. 1897. (10c.)
New Brunswick geology, by R. W. Ells. 1887. (10c.)
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900. (50c.)
799. Carboniferous system in N.B., by L. W. Bailey. 1900. (10c.) } Bound together.
803. Coal prospects in N.B., by H. S. Poole. 1900. (10c.) } Bound together.
871. Pictou coal field, by H. S. Poole. 1902. (10c.)

IN PRESS.

970. Report on Niagara Falls, by Dr. J. W. Spencer.
968. Report to accompany map of the Moose Mountain area, Alta., by D. D. Cairnes.
974. Copper Bearing Rocks of Eastern Townships, by J. A. Dresser. (10c.)
980. Similkameen district, B.C., by Chas. Camsell. (10c.)
982. Conrad Mining district, Yukon, by D. D. Cairnes. (10c.)
988. Telkwa valley, B.C., by W. W. Leach. (10c.)

IN PREPARATION.

Rossland district, B.C. (full report), by R. W. Brock.
Report on Prince Edward county, Brockville and Kingston map-sheet, by R. W. Ells.
Report on Cornwall sheet, by R. W. Ells.
Reports on Country between Lake Superior and Albany river, by W. J. Wilson and W. H. Collins.
Transcontinental location between Lake Nipigon and Sturgeon lake, Ont., by W. H. Collins.
Nanaimo and New Westminster districts, B.C., by O. E. LeRoy.

(B.—*Published by the Mines Branch.*)

On the location and examination of magnetic ore deposits by magnetometric measurements. Eugene Haanel. 1904.

Report of the Commission appointed to investigate the different electro-thermic processes for the smelting of iron ores and the making of steel in operation in Europe. (Only a few copies of this report are available.) By Eugene Haanel. 1904.

Final report on the experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Eugene Haanel. 1907.

Preliminary report on the Limestones and the Lime Industry of Manitoba. J. W. Wells. 1905.

Preliminary report on the raw materials, manufacture and uses of Hydraulic Cements in Manitoba. J. W. Wells. 1905.

Preliminary report on the industrial value of the Clays and Shales of Manitoba. (Only a few copies available.) J. W. Wells. 1905.

Mica, its occurrence, exploitation and uses. Fritz Cirkel. 1905. (Only a few copies available.)

Asbestus, its occurrence, exploitation and uses. Fritz Cirkel. 1905.

Report of the Commission appointed to investigate the Zinc Resources of British Columbia and the conditions affecting their exploitation. W, R. Ingalls. 1905.

Report on the present and prospective output of the Mines of the Silver-Cobalt ores of the Cobalt District. Eugene Haanel. 1907.

Report on the Mining Conditions of The Klondike, Yukon. Eugene Haanel. 1902.

IN PRESS.

Monograph on Graphite. Fritz Cirkel.

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Receptaculites occidentalis, Salter. No. 764, H. M. A. 1880.

Calapœcia canadensis, Billings, No. 757, Donor: Geological Survey.

Columnaria alveolata. (=*Columnaria halli*, Nicholson,) No. 1867. Dr. D. K. Cowley.

Petraia cornicula, Hall. No. 741.

Petraia profundo, (=*Streptelasma profundum*, Hall) No. 742. R. J. B. Howard, 1879.

Orthis tricenaria, Conrad, No. 709, R. J. B. Howard, Esq. 1879.

Strophomena, sp. (A slab of limestone with several specimens of *Strophomena incurvata*, Shepard, the *Streptorhynchus filitextusum*, of Hall, and authors generally). No. 968. Also *Murchisonia bellicincta* on the same slab.

Bellerophon charon, Billings. H. M. A. 1880.

Helicotoma planulata, Salter, H. M. A. 1880.

There is a specimen labelled *Helicotoma larvata*, which is evidently *H. planulata*, Salter, No. 694, R. J. B. Howard, Esq., 1879.

Murchisonia gracilis, Hall, No. 660, R. J. B. Howard, Esq., 1879.

(Another specimen, No. 667 is silicified and was collected by the same person, same date.)

Murchisonia bicincta, Hall. (=*Murchisonia milleri*, Hall); (=probably *Hormotoma bicincta*, Hall) No. 6, 62, Donor: Geological Survey.

Murchisonia bellicincta, Hall. No. 681, Two specimens: One silicified, the other not, the latter is a dolomitized cast of the interior of a specimen.

Ctenodonta gibbosa, Salter, H. M. A. 1880. *Ctenodonta nasuta*, Conrad. No. 690, J. Richardson,

Ctenodonta nasuta, Conrad, H. M. A. 1880.

GEOLOGICAL SURVEY OF CANADA.

A. P. LOW, Deputy Head and Director.

REPORT

ON

GOLD VALUES

IN THE

KLONDIKE HIGH LEVEL GRAVELS

BY

R. G. McCONNELL.

OTTAWA
GOVERNMENT PRINTING BUREAU
1907

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(SINCE 1885)

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857. Infusorial Earth.
858. Manganese.
859. Salt.
860. Zinc.
869. Mica.
872. Molybdenum and Tungsten.
877. Graphite.
880. Peat.
881. Phosphates.
882. Copper.
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GEOLOGICAL SURVEY OF CANADA.

A. P. LOW, Deputy Head and Director.

no.5

REPORT

ON

GOLD VALUES

IN THE

KLONDIKE HIGH LEVEL GRAVELS

BY

R. G. McCONNELL.

OTTAWA:
GOVERNMENT PRINTING BUREAU.
1907.

No. 979.

A. P. Low, Esq.,
Director, Geological Survey.

Sir,—I beg to transmit the following report on work done in the Klondike during the past season.

The object of the season's work was to estimate the recoverable values remaining in the high level gravels along Bonanza and Hunker creeks and a portion of the Klondike valley, and also to obtain as much information as possible in regard to the values remaining in the low level or creek gravels.

The necessity of completing this work in a single season compelled us to make a somewhat hurried examination, but we were successful in covering the whole field in a fairly satisfactory manner.

I was efficiently assisted during the season by Jos. Keele, geologist, and Messrs. F. H. McLaren and F. O'Farrell, topographers, to whom the measurements of the various areas were entrusted. I was also fortunate enough to secure the services, among others, of such experienced and trustworthy miners as Robert Henderson, the discoverer of the Klondike, and A. B. McDonald. Valuable assistance was also obtained from Mr. A. J. Beaudette, territorial mining engineer, and from many miners engaged in active work on the various creeks and benches.

I have the honour to be, sir,
Your obedient servant,

R. G. McCONNELL.

Ottawa, April 12, 1907.

CONTENTS.

REPORT

ON

GOLD VALUES IN THE KLONDIKE HIGH LEVEL GRAVELS

BY

R. G. McCONNELL

A general report by the writer on the geology, topography and gold-bearing gravels of the Klondike district was published by the Geological Survey in 1905. The present report, although a few other subjects are briefly discussed, is special in its object and deals principally with the values still remaining in the Bench and Creek gravels and especially in the important high level deposit known as the White Channel gravels.

Classification of Gravels.

Low level gravels....................	Gulch gravels. Creek gravels. River gravels.
Gravels at intermediate levels	Terrace gravels.
High level bench gravels.	Klondike gravels. White Channel gravels.

The gravels enumerated in this table are fully described in the report referred to above and only certain points on which additional information was obtained need be treated at length. The diagram on page twenty-one shows the relationship of the various types on the lower part of Bonanza creek.

The White Channel bench or hill gravels are the oldest in the district, and, excepting the present creek gravels, the most important from an economic standpoint. They were originally creek gravels, deposited in a similar manner to those occupying the low levels at present, and their

elevated position is due to an uplift which affected the whole region bordering the Yukon from the Stewart river northwest to the Alaskan boundary and for a considerable distance beyond. This uplift, and a small depression which preceded it, produced many notable changes in the topography of the country.

It is probable, although not conclusively proved, that during the White Channel period the lower portion of the Klondike valley, the portion into which the principal gold-bearing creeks discharge, was occupied by a small local stream and that the Klondike itself flowed either into the Stewart or into Twelve-mile river. The White Channel deposits are remarkable in this respect that even when completely destroyed their former position is marked by a trail of gold. They are traceable in this manner from the present mouth of Hunker, Bear and Bonanza creeks far out into the present valley of the Klondike, showing that the old valley was small, smaller than that of Hunker creek and unlikely to have contained a large rapid river such as the Klondike.

At the close of the White Channel period the district was depressed, and it was during this depression that the Klondike is considered to have broken into its present valley. It brought down an immense quantity of material from its upper reaches, and rapidly built up a wide gravel bed fully 150 feet in depth. These gravels at the mouth of Hunker and Bonanza creeks rest on the White Channel deposits and at other points, where not destroyed, are distributed along the hill sides at the same level. They are composed principally of well-rounded pebbles of quartzite, hard slate, diorite and occasionally granite, all, unlike the other gravels, foreign to the district, and so far not proved to be of much economic importance.

The depression was followed by an uplift of approximately 700 feet, which gave new life to all the streams by increasing their grades, and they immediately commenced to deepen their channels. This process was continued not only through the old gravel deposits but down into the bedrock to a depth of from 150 to 300 feet. The new valleys are sunk, as a rule, through the bottom of the old ones, but in a few places, as at the mouth of Bonanza creek, they deviate from them and have carved out independent courses.

The difference in character between the old and new valleys is striking. The old ones represent the product of long continued stable conditions, and are characterized by wide flats and gently sloping sides, from which all traces of angularity have been smoothed away. The flats of the old Hunker Creek valley have a width in places of over a mile. The new

valleys on the other hand, while opening out into occasional basins, are generally narrow, steep-sided and angular. This applies only to the creeks, all of which are small, as the Klondike river has cut a huge trench through the district since the uplift.

Only a portion of the deposits of the old valleys was destroyed during the excavation of the recent valleys, as the latter are much narrower and do not follow exactly the same courses. The undestroyed portions constitute the White Channel gravels of the miners.

Character of White Channel Gravels.

The White Channel gravels differ somewhat from the ordinary type of stream deposit. They are very compact as a rule and in some of the hydraulic cuts stand up in almost vertical cliffs, even when the face is unfrozen. The white or light grey coloration from which the deposit derives its name is very conspicuous in most of the sections but is not universal, as red, yellow and dark grey beds frequently occur. The deposit is highly siliceous, the principal constituent consisting of rounded pebbles and rounded and subangular boulders of vein quartz. Flat schist pebbles and boulders, usually in a more or less advanced stage of decomposition, occur with the quartz, and also occasional pebbles derived from the various dikes and stocks outcropping along the valleys. No material foreign to the district occurs in the deposit. The pebbles and boulders are usually small, seldom exceeding eighteen inches in diameter, and are embedded in a compact matrix consisting essentially of small sericite plates and fine angular quartz grains. A few large angular blocks from three to four feet in diameter are occasionally met with but are rare and usually occur on or near bedrock.

The uniformity of the deposit in composition and general character throughout sections a hundred feet or more in thickness is very striking. The bedding planes, as a rule, are inconspicuous, and there has been no sorting of the various constituents into separate beds.

The deposits, unlike the creek and gulch gravels, appear to be destitute of vegetable and animal remains. None were found by the writer and the few reported discoveries by miners lack confirmation.

The thickness of the White Channel gravels varies from a few feet to 150 feet and the original width from a couple of hundred yards to over a mile. The volume of the deposit on both Hunker and Bonanza creeks increases steadily down stream.

On Gold, Adams and other hills on Bonanza creek the typical compact white variety of the White Channel deposit is replaced towards the sides of the old valley by flat rusty coloured gravels, more loosely bedded and containing a smaller proportion of quartz than the ordinary white variety. These probably represent flood plains deposits. They have the appearance of overlying the white variety and were formerly, in the absence of sections, considered to be younger. The long exposures, however, now available for study in the various hydraulic cuts, show that the two varieties pass gradually one into the other both horizontally and vertically and in places are interbanded, evidence of contemporaneous deposition. The loose yellow variety is seldom productive.

The White Channel gravels were probably deposited by winding streams with easy grades and comparatively slack currents. The preponderance of vein quartz pebbles and boulders, the most resistant rock in the district, gives them the character of a residual deposit. They were built up slowly and in the long process the softer rocks were mostly destroyed and carried away.

The great length of the White Channel period is indicated by the enormous gold accumulations, all derived from the slow breaking up of auriferous quartz veins which took place in it. Since the close of the period the additions to the supply have been trifling, although a sufficient time has elapsed to enable small streams to excavate channels, mostly through hard schists from 300 to 600 feet in depth. Practically all the gold in the present low level valley flats is of secondary origin and derived from the partial distribution of the older gravels.

The age of the White Channel gravels has not been determined, but they must date back to the Pleiocene at least. They were certainly deposited before the advent of the present severe climatic conditions, as the white coloration is largely due to the leaching out of the greater portion of the iron by circulating surface waters, and this must have taken place before they were permanently frozen.

Distribution of Gold in Gravels and Bedrock.

The greater part of the gold both in the hill and creek gravels occurs on or near bedrock, either in the lower four to six feet of gravel or sunk for some distance in the bedrock itself. The distribution depends largely on the character of the bedrock. Soft schists such as those underlying the rich portion of Upper Dominion creek prevent the gold from descending, and it accumulates in a thin layer at the base of the

gravels. In many of the rich claims between the two discoveries on Dominion creek a thin stratum of gravel resting immediately on bedrock proved extraordinarily rich, while the bedrock and the upper gravels were comparatively lean. On Bonanza creek the bedrock as a rule is harder and more flaggy, and the action of frost has parted the layers and allowed a portion of the gold to descend along them. From three to five feet of bedrock are usually mined at a profit, and gold has been found in some quantity at a depth of twelve feet and probably descends still deeper.

On a couple of claims on Hunker creek below the mouth of Seventy pup practically all the gold occurred in a shattered porphyry bedrock, the overlying gravels proving almost barren.

The bedrock underlying the Hill or White Channel gravels is more decomposed than that in the creek bottoms, does not open out in the same way and retains most of the gold at or near the surface. In a few places gold has been found in paying quantities in the schist partings under the decomposed layer, but as a rule only the upper few inches are mined.

The rapid decrease in gold values in the White Channel gravels above bedrock is shown in the following table which gives the average values obtained in sampling Trail and Lovett hills. The samples were taken in successive six foot columns.

					Total value.
144–150	feet.	Average value per	cubic yard,	.006....	.012
138–144	"	"	"	.007....	.014
132–138	"	"	"	.008....	.016
126–132	"	"	"	.009....	.018
120–126	"	"	"	.009....	.018
114–120	"	"	"	.010....	.020
108–114	"	"	"	.010....	.020
102–108	"	"	"	.011....	.022
96–102	"	"	"	.011....	.022
90–96	"	"	"	.012....	.024
84–90	"	"	"	.013....	.026
78–84	"	"	"	.015....	.030
72–78	"	"	"	.020....	.040
66–72	"	"	"	.020....	.040
60–66	"	"	"	.021....	.042
54–60	"	"	"	.023....	.046
48–54	"	"	"	.025....	.046

			Total value.
42–48 feet.	Average value per cubic yard	.045....	.090
36–42 "	" "	.030....	.060
30–36 "	" "	.032....	.064
24–30 "	" "	.034....	.068
18–24 "	" "	.040....	.080
12–18 "	" "	.047....	.094
6–12 "	" "	.180....	.360
1–6 "	" "	$4.130....	8.260
Total values in square yard column fifty yds. high.			$9.532

The values in the lower four yards, including a foot of bedrock, average $2.15 per cubic yard, while those in the upper forty-six yards of the column average less than two cents per cubic yard. The decrease in values from the bottom to the top of the section proved to be constant, except at one point forty-five feet above bedrock where a slight enrichment takes place.

The following table shows the values obtained in a square yard column of the White Channel gravels in the Last Chance Creek slope of Dago hill:—

			Total value.
84–90 feet.	Average value per cubic yard,	.007....	.014
78–84 "	" "	.009....	.018
72–78 "	" "	.012....	.024
66–72 "	" "	.014....	.028
60–66 "	" "	.020....	.040
54–60 "	" "	.0675...	.135
48–54 "	" "	.0275...	.055
42–48 "	" "	.030....	.060
36–42 "	" "	.041....	.082
30–36 "	" "	.040....	.080
24–30 "	" "	.0425...	.085
18–24 "	" "	.050....	.100
12–18 "	" "	.060....	.120
6–12 "	" "	.114....	.228
1–6 "	" "	$2.200....	$4.400
Total values in square yard column thirty yds. high.			$5.469

In this column a considerable enrichment takes place at a point sixty feet above bedrock. The enriched gravels have a thickness of a few

inches only and rest on a compact clayey stratum not easily penetrable which acts as a bedrock. The gold is moderately coarse, much coarser than that in the gravels immediately above and below, but finer than that on bedrock.

A marked exception to the general rule in the district, that the gold decreases in quantity and coarseness from bedrock upwards, occurs on Paradise hill on Hunker creek. The main gold zone here in many places is found not in bedrock but at elevations of from three to twelve feet or more above it. A section of the gravels twenty-four feet thick a short distance below Hester creek gave the following values:—

18–24 feet.	Average per cubic yard,	$	0.025	....	$0.050
12–18 "	"	"	0.266	....	.532
6–12 "	"	"	0.776	....	1.552
1–6 "	"	"	0.576	....	1.152
Total values in square yard, column eight yds. high ..					$3.286
Average values per cubic yard......................					42.1 cents.

The lower gravels in this section and in other places on the hill are very siliceous, consisting almost entirely of vein quartz pebbles and boulders. The siliceous layer varies in thickness from a few inches up to eight or ten feet, and is overlaid by gravels containing a greater proportion of schist pebbles. The best drifting ground worked so far occurs above the siliceous layer, in the lower part of the upper gravels.

The gravels on Paradise hill although rich in places have seldom paid to drift on account of this irregular distribution of the gold. The pay zone, in place of lying in a plane, undulates along the surface of the uneven siliceous gravels and is very difficult to follow.

The concentration of all the coarse, and the greater part of the fine, gold in the White Channel gravels on or near bedrock seems incapable of explanation except on the assumption that the gravels have been worked over probably several times by the stream that deposited them. The deposit is over 150 feet thick in places, is very compact and includes numerous medium sized and a few large angular boulders which would serve to intercept a portion of the gold if it descended under the influence of gravity alone. That they have not done so is shown by the fact that in all our sampling not a single coarse piece was found in the upper gravels.

Grade of Klondike Gold.

Klondike gold varies greatly in grade not only on different creeks but also along different portions of the same creek. The difference of grade is due to the gold being in all cases alloyed with silver in varying proportions. The lowest grade gold in the camp occurs on Big Shookum and Henry gulches and has a value of about $12.50 per ounce. The highest grade gold on the Klondike creeks is found on Upper Hunker creek where assays occasionally exceed $17.50 per ounce. The gold from Gold Run creek on the Indian River slope averages over $17.50 per ounce and assays of $17.75 per ounce are reported from Allgold creek.

The average value of all the gold shipped from the camp in 1905 according to the U. S. Mint returns amounted to $16.02 in gold and 10.94 cents in silver per ounce.

In the lowest grade gold the silver almost equals the gold in volume, the ratio being 1 to 1.4. In the high grade gold the ratio is 1 to 5 and the general average is 1 to 2.3. In value the ratio of silver to gold is very small, the proportion calculated from a number of returns being approximately 1 to 150. The total gold production of the camp is estimated at $119,000,000 and the silver at $793,000.

The variations in grade along the different creeks, as shown by assays furnished by the Bank of Commerce, are interesting. Bonanza Creek gold above Eldorado forks is fairly uniform in grade, running from $16.73 to $17.09 per ounce. The average grade decreases slightly but not uniformly down stream. Below the Eldorado forks the influence of the inferior Eldorado gold is shown by a sudden decrease in value to about $16.00 per ounce. Farther down in the rich section above discovery claim the grade drops to $15.75 per ounce. Below discovery claim the value increases to about $16.15 per ounce and remains at that figure down into the Eighties, a distance of eight miles. Towards the mouth of the creek the grade again increases to over $16.50 per ounce.

Eldorado Creek gold has an average value of $15.70 per ounce, about a dollar less than that from Bonanza creek above the forks. The difference in grade is somewhat remarkable as the two streams cut the same rocks, are never far apart, and must have drawn at least a portion of their supplies from a common source, viz.: the comparatively narrow ridge separating them. Gulches cutting back into this ridge from both creeks have proved productive. Eldorado gold is generally coarser than that from Bonanza creek, and its inferior grade may be due to this cause,

as fine gold everywhere throughout the camp assays higher than the accompanying coarse gold.

The grade of Hunker Creek gold is extremely variable, ranging from over $17.50 per ounce in the upper part of the creek down to $14.50 below Henry gulch. The grade decreases slowly down stream from discovery claim to Hester creek, then drops suddenly over a dollar an ounce. Paradise Hill gold below Hester creek averages about $15.20 per ounce. Farther down on Dago hill the grade increases again to $16.50 per ounce, then drops down to $14.50 per ounce near the mouth of the creek. Last Chance creek, a tributary of Hunker creek, and Bear creek, a parallel stream emptying into the Klondike, both contain low grade gold, assays seldom exceeding $15 per ounce.

The Indian River creeks average higher in grade than Klondike River creeks. Dominion Creek gold above Gold Run averages about $16.90 per ounce. Below Gold Run the grades increase to $17.50 per ounce. Gold Run gold maintains an average grade along the main pay streak of fully $17.50 per ounce. Sulphur Creek gold is somewhat lower, averaging about $16.50 per ounce.

The variation in grade of the placer gold appears to depend mostly on original differences in grade of the vein gold from which it was derived. Creeks draining certain areas in the district carry low grade gold, while other areas supply high grade. An important centre of dispersion for low grade gold occurs west of the lower portion of Hunker creek. Hester and Last Chance creeks, Henry gulch and Bear creek all head in the same ridge within a comparatively short distance of each other and all carry low grade gold. Big Shookum creek, a tributary of Bonanza creek, heads in a low grade area and the gold brought down by it lowers appreciably the general grade of the Bonanza Creek gold for several claims. The Dome and surrounding region furnishes a good example of a high grade area. The streams flowing outwards from this centre, including Upper Dominion, Upper Hunker, Sulphur and Gold Bottom creeks, all carry high grade gold although the values differ considerably.

While the grade of the placer gold is supposed to conform in a general way with that of the original vein gold some changes are evidently produced by the leaching out of a portion of the silver contents.

Mr. M. Carey Lea in a series of articles in the American Journal of Science, commencing in Vol. XXXVII, p. 491, has shown that silver passes readily when treated with certain re-agents into an allotropic form, one of

the distinguishing characters of which is its easy solubility, and the same process may go on in nature.

Evidence of loss of silver is afforded by the fact that fine gold which would necessarily be affected more by leaching than the accompanying coarse gold invariably carries a smaller percentage of silver.

Nuggets also assay higher as a rule on the surface than in the centre. Five assays of selected nuggets made by Mr. Connor in the laboratory of the Survey gave the following results:—

	Centre of nugget.	Surface.	
1 Silver....	35.8	29.4	Trail hill, Bonanza creek.
Gold.....	64.2	70.6	
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Gold.....	60.1	66.5	
3 Silver....	37.3	30.3	Bonanza creek, No. 12 below.
Gold.....	62.7	69.7	
4 Silver.....	46.1	41.0	Treasure hill, Last Chance creek.
Gold.....	53.9	59.0	
5 Silver.....	33.0	33.5	Bonanza creek, No. 3 below.
Gold.....	67.0	66.5	

All the nuggets with the exception of No. 5 show losses in silver of from five to seven per cent on the surface, assuming that the composition was originally uniform. No. 5 was a large nugget filled with quartz and its exceptional character is probably due to its being much younger than the others.

Transportation of Gold.

The two main factors in the transportation of coarse gold by natural causes are grade and bedrock. With steep grades and smooth bedrock transportation is comparatively rapid, while little movement takes place when the grades are moderate and the valleys are floored with the tilted flaggy schists characteristic of the district.

The Klondike slopes are everywhere mantled with a thick covering of broken and partially decomposed schist fragments easily moved when not frozen and ever tending downwards towards the creek and gulch levels. The downward movement is slow and intermittent at present on account of the perpetually frozen condition of the surface, except on sunny slopes. During the period of the White Channel gravels,

the period of the great gold accumulations, climatic conditions were less severe and the movement must have been much more rapid.

The slide material carries with it the gold and gold-bearing quartz released by the breaking up of the auriferous quartz veins, and when running water is reached the gold is sluiced out and remains behind, while the rock fragments are ground up and carried away.

The distance travelled by the gold after reaching the waterways, neglecting the time element, depends on the grades and bedrock. The upper portions of the creeks, and the steep gulches, except where they cross the paystreak of the White Channel gravels and are directly enriched from them, have not proved rich and are only occasionally productive. The gold washed down into them moves slowly on, and all the great accumulations occur on portions of the creeks with grades of 150 feet or less to the mile. The rate of movement diminishes rapidly with the grade and near the mouths of the creeks is excessively slow.

Evidence of the tardy movement of coarse gold down streams of moderate grade, even where the latter are actively engaged in eroding their channels, is furnished at many points along Bonanza and Hunker creeks. The paystreak of the elevated White Channel gravels has been destroyed in places along both these streams. Whenever this occurs the creek bottoms directly opposite the destroyed portions are immediately enriched, showing that the gold, or a large portion of it at least, has remained almost stationery during all the time the creeks were employed in deepening their channels from 150 to 300 feet. The horizontal movement in some instances scarcely exceeds the vertical movement. The complementary relationship existing between the creek and the hill pay gravels has been recognised by the miners, and whenever the creek gravels are lean, pay is confidently expected on the hills, and in the productive portions of the creeks is usually found.

The influence of bedrock in retarding or accelerating the progress of gold down stream is almost as important as that of grade. The common bedrock of the district is a light coloured flaggy sericite schist of unequal hardness and usually tilted at high angles. The sericite schist alternates in places with bands of dark graphitic schists and is broken through by numerous porphyritic dikes and stocks. The light coloured flaggy schists when hard form an excellent bedrock from the miner's point of view as they weather unequally into irregular rock ripples which arrest the progress of the gold. The partings also open out under the influence of the alternate freezings and thawings to which the rocks are subjected and the gold descends along them, and continues to descend

as the surface is gradually lowered by erosion. Its progress down stream when caught in this manner is indefinitely delayed.

The porphyritic rocks when shattered, as is often the case, also arrest most of the gold. The soft varieties of the sericite schists and the dark graphitic schists, on the other hand, offer small resistance to the passage of the gold. They weather to a smooth surface along which the gold moves easily, and the portions of the creeks underlaid by them are usually lean.

Valuation of High Level Gravels—Method employed.

All the high level gravels along Hunker and Bonanza creeks, and the Klondike river below Hunker creek, considered to be of economic importance, were measured as accurately as conditions permitted. Two six inch stadia transits were used for this purpose and proved very satisfactory. The outlines of most of the areas could be defined very closely as nearly all the hills have been thoroughly prospected by drifts and shafts. In a few places where the surface is muck-covered the back limit of the gravels could only be drawn approximately, but the total error from this source is not believed to be large. The aggregate volume of gravels measured amounted to 354,000,000 cubic yards.

Sampling was carried on continuously throughout the season and all the important hill areas, except the Upper Bonanza hills, were examined as carefully as the time at our disposal allowed.

The sampling was done with rockers built specially for the purpose. The usual sample consisted of a column of gravel a foot square, each successive six foot section being washed separately. When the gravels were shallow continuous sections from the bottom to the top of the deposit were washed. In the deeper deposits continuous columns of the lower gravels only were washed. Above a height of thirty-six feet samples were taken at intervals of about twenty feet.

On most of the important hills long faces opened out by hydraulic operations, and numerous drifts and shafts were available for examination. Where these were absent shallow cuts and shafts were sunk at intervals by ourselves.

In estimating the gold contents of the various gravel areas due allowance was paid to the statements of miners in regard to the values obtained in drifting and hydraulic operations. In most cases the values given agreed very closely with the result of our own work.

Magnet, American and Orofino hills and a portion of Bonanza creek
View looking north from Adams hill.

The estimate of values in the Upper Bonanza hills and in the low level creek gravels is based almost entirely on the results of actual mining work and on information (carefully examined and sifted) obtained from miners and others familiar with the ground. The gravels have all been more or less mined and the remaining values are distributed so irregularly that effective sampling in the time at our disposal was obviously impossible.

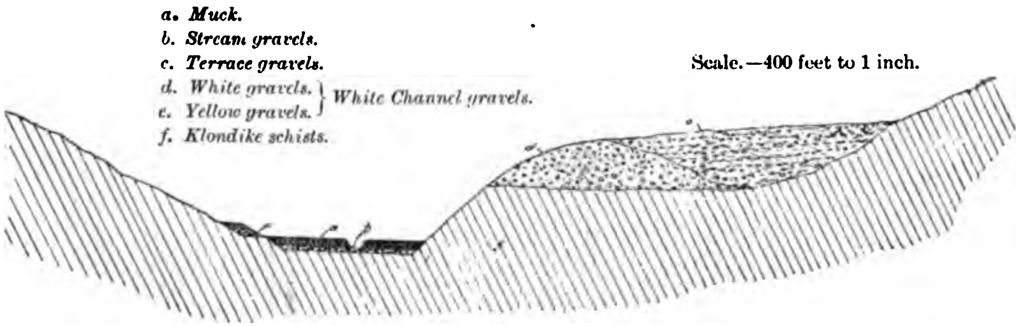
The values in the smaller hills, many of which are held separately, are grouped together in order to avoid affecting individual interests. The larger hills as a rule are divided up among a number of different owners.

Bonanza Creek High Level Gravels.

The White Channel gravels once continuous along Bonanza creek and its main tributaries have been partially destroyed by the deepening of the valleys, and have been cut through transversely at various points by tributary creeks and gulches. They are now represented by a number of separated areas distributed at irregular intervals along the valleys and designated by the miners by different names. With the exception of French hill on Eldorado creek none of the areas on the tributary streams have proved of much importance.

The White Channel gravels on Bonanza creek above the Eldorado forks, and on Eldorado creek, have been mostly destroyed and the gold contents washed down into the present low level valleys. The extraordinary richness of these valleys is due to this fact. The principal areas which have been preserved are Bunker hill, below Gauvin gulch on Bonanza creek, and French hill below French creek on Eldorado creek. Besides these, small patches, now mostly worked out, have been preserved on Bonanza creek below McKay and Homestake creeks and on Eldorado creek above Oro Grande gulch.

The most important strip of hill gravels on Bonanza creek at present commences at the Eldorado forks and extends down stream on the left limit to Boulder creek, a distance of about four miles. The gravels do not form a continuous stretch as they are cut across by Adams and Boulder creeks and various gulches, and separated into a number of areas known as Gold, Chechaco, Adams, Magnet, American, Orofino, Monte Cristo, King Solomon and Boulder hills. The gravel areas border the present secondary valley and extend back for distances varying from 800 feet on Magnet hill to 2,500 feet on King Solomon hill. The thickness ranges from a few feet up to 150 feet.



GENERALIZED SECTION ACROSS BONANZA VALLEY BELOW ELDORADO FORKS.

The volumes of gravel on the Upper Bonanza and Eldorado hills are as follows:—

Bunker hill	1,050,000	cu. yds.
French hill	1,670,360	"
Gold hill	3,684,940	"
Chechaco hill	5,805,236	"
Adams hill	7,561,370	"
Magnet hill	485,672	"
American hill	2,210,888	"
Orofino hill	6,892,130	"
Monte Cristo hill	3,710,490	"
King Solomon hill	10,780,587	"
Boulder hill	1,475,216	"
Total volume	45,326,889	"

A paystreak varying from 200 to over 400 feet in width has been traced through all these hills. It is partly destroyed in places, but on some of the hills, notably on Orofino and Monte Cristo, it is situated some distance back from the present secondary valley and is entirely preserved.

The gravels in the paystreak of all these Upper Bonanza hills proved rich everywhere, and, in places, the values returned appear almost fabulous. Whole claims are reported to have averaged from $60.00 to $100.00 per square yard of bedrock. Portions of French, Gold, Chechaco and Magnet hills were particularly rich and yields of a dollar a pan, or $150.00 per cubic yard for the lower four or five feet of gravel, are stated to have been obtained from small areas on these hills.

The paystreak is now practically drifted out, portions of it twice over, and is estimated to have yielded gold to the value of $24,000,000.

Drifting operations, however, never result in a full extraction of the gold. A few pillars and occasional small areas are usually neglected for various causes; the bedrock is seldom thoroughly mined and no attempt is, of course, made to recover the values in the upper lean gravels. The paystreak gravels are also bordered as a rule on both sides by considerable fringes of gravel, too lean to drift but rich enough in most cases to hydraulic.

The gravels in the Upper Bonanza hills, considered rich enough to be hydrauliced at a profit, include all those in the original paystreak, hose in a band behind the paystreak varying in width on the different

the distinguishing characters of which is its easy solubility, and the same process may go on in nature.

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LOVETT HILL AND MOUTH OF BONANZA CREEK.
View looking south across the valley of the Klondike river.

hills from 100 to 200 feet and those between the paystreak and the present valley. The gravels in the back portion of most of the hills are too lean to be worked by any method.

The volumes of workable gravels on the various hills are estimated as follows:—

Bunker	850,000	cu. yds.
French	570,360	"
Gold	1,779,650	"
Chechaco	3,752,914	"
Adams	2,379,000	"
Magnet	395,677	"
American	1,989,218	"
Orofino	5,533,000	"
Monte Cristo	1,853,150	"
King Solomon	4,681,087	"
Boulder	332,000	"
Total	24,116,056	"

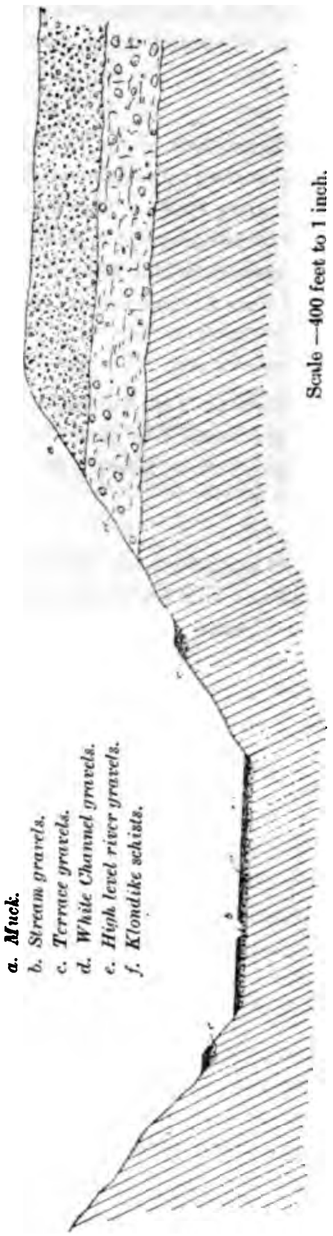
The average values in these gravels are estimated at 34.05 cents per cubic yard and the amount of recoverable gold at $8,213,532. These figures are based on the results of the small hydraulic operations now in progress on most of the hills and on information obtained from private sources. The values are distributed so irregularly that it was considered a closer estimate could be formed in this way than by a limited amount of sampling done by ourselves.

Lower Bonanza Hill Gravels.

Between Boulder and Cripple hills, a distance of three miles, the hill gravels bordering Bonanza creek are unimportant. A few small areas have been preserved at various points on both sides of the valley but these represent largely the lean rim gravels of the old deposit. The central portion containing the paystreak has been almost entirely destroyed.

Below Cripple creek pay gravels are again preserved on the benches, but occur on the right limit, the paystreak having crossed the valley. They extend through from Cripple creek to the Klondike valley, a distance of three miles, except where cut across by Trail and Lovett gulches. These gulches separate the gravels into three areas known as Cripple, Trail and Lovett hills.

LOVETT HILL AND MOUTH OF BONANZA CREEK.
View looking south across the valley of the Klondike river.



GENERALIZED SECTION ACROSS THE LOWER PART OF BONANZA VALLEY.

Below Cripple creek the present Bonanza valley bends to the left away from the old valley and joins the Klondike some distance lower down. In consequence of this divergence only a small proportion of the gravels of the old valley on Trail and Lovett hills has been destroyed and the paystreak, except where cut transversely by gulches, has been preserved intact.

The volume of White Channel gravels on Lovett hill exceeds 71,000,000 cubic yards, an amount almost equalling the combined volumes on all the other hills bordering Bonanza creek. The deposit has a thickness in the centre of the channel of 168 feet and a width of 5,200 feet. It occupies a wide shallow depression in the Klondike schists and is overlaid and overlapped on both rims by 150 feet of younger gravels deposited by the Klondike river.

The White Channel gravels on Trail hill above Lovett hill have a thickness of 230 feet. They are overlaid in places by Klondike River gravels but are not completely buried as on Lovett hill.

The volumes of White Channel gravels and overlying Klondike gravels on the three lower Bonanza hills are as follows:—

Cripple hill (White Channel gravels)	7,820,460	cu. yds.
Trail hill (partly Klondike gravels)....	22,235,390	"
Lovett hill (White Channel gravels)......	71,366,370	"
" (Klondike River gravels).......	66,997,230	"
Total...........................	168,419,450	"

These figures include all the White Channel gravels both in and off the paystreak, but only those portions of the Klondike River gravels which overlie the White Channel gravels and which would be required to be washed away if the latter were hydrauliced.

These lower Bonanza hills, although originally much lower in grade than the Upper Bonanza hills, are now almost as important economically, as they have been mined to a much less extent. The production to date is estimated at $750,000, mostly obtained by drifting.

The paystreak is remarkably wide and very uniform in grade. It is partially destroyed on Cripple hill but on Trail and Lovett hills where fully preserved has a width of from 1,000 to 1,400 feet.

The workable gravels are practically limited to the paystreak. The volumes are estimated as follows:—

Cripple hill—White Channel gravels	614,910	cu. yds.
Trail hill—Mostly White Channel gravels	11,802,250	"
Lovett hill { White Channel gravels	23,503,770	"
Lovett hill { Overlying Klondike River gravels	14,511,760	"
	50,432,690	"

The average grade of these gravels is estimated at 14.9 cents per cubic yard and the amount of recoverable gold in the three hills at $7,528,720.

The low general average, notwithstanding values of over a dollar per square foot of bedrock, is due to the exceptional thickness of the gravels over the greater portion of Lovett hill, amounting to fully 300 feet, of which the upper 200 feet are practically barren. The values in Cripple and Trail hills, and the rim portions of Lovett hill, considerably exceed the general average, while those in the central portion of Lovett hill are somewhat less.

Summary of Bonanza Creek workable Hill Gravels.

	Volume.		Estimated Values.
Upper Bonanza hills	24,116,056	cu. yds.	$ 8,213,532
Lower Bonanza hills	50,432,690	"	7,528,720
Total	74,548,746	"	$15,742,252

Average estimated yield per cubic yard, 21.1 cents.

Total quantities of high level gravels along Bonanza creek.

Upper Bonanza hills (White Channel gravels)	45,326,889	cu. yds.
Small hills between Boulder and Cripple hills not measured, estimated at	3,500,000	"
Lower Bonanza hills (partly Klondike gravels)	168,419,450	"
	217,246,339	"

Hunker Creek White Channel Gravels.

Bench gravels belonging to the White Channel period are extensively developed along Hunker creek but are much lower in average grade than

hills from 100 to 200 feet and those between the paystreak and the present valley. The gravels in the back portion of most of the hills are too lean to be worked by any method.

The volumes of workable gravels on the various hills are estimated as follows:—

Bunker	850,000	cu. yds.
French	570,360	"
Gold	1,779,650	"
Chechaco	3,752,914	"
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Monte Cristo	1,853,150	"
King Solomon	4,681,087	"
Boulder	332,000	"
Total	24,116,056	"

The average values in these gravels are estimated at 34.05 cents per cubic yard and the amount of recoverable gold at $8,213,532. These figures are based on the results of the small hydraulic operations now in progress on most of the hills and on information obtained from private sources. The values are distributed so irregularly that it was considered a closer estimate could be formed in this way than by a limited amount of sampling done by ourselves.

Lower Bonanza Hill Gravels.

Between Boulder and Cripple hills, a distance of three miles, the hill gravels bordering Bonanza creek are unimportant. A few small areas have been preserved at various points on both sides of the valley but these represent largely the lean rim gravels of the old deposit. The central portion containing the paystreak has been almost entirely destroyed.

Below Cripple creek pay gravels are again preserved on the benches, but occur on the right limit, the paystreak having crossed the valley. They extend through from Cripple creek to the Klondike valley, a distance of three miles, except where cut across by Trail and Lovett gulches. These gulches separate the gravels into three areas known as Cripple, Trail and Lovett hills.

LOVETT HILL AND MOUTH OF BONANZA CREEK.
View looking south across the valley of the Klondike river.

those on Bonanza creek. They have been mined at various points both by the drifting and hydraulic methods with an estimated production up to the present of $2,500,000, the greater part of which came from Whisky hill, a small rich hill in the upper part of the valley. The generally inferior average grade of the Hunker Creek hill gravels as compared with those on Bonanza creek is due partly to their leaner condition originally, and partly to the fact that along the richest portions of the creek the paystreak of the old valley has been almost entirely destroyed and the gold contents washed down to the level of the present valley.

Upper Hunker Creek Hill Gravels.

The White Channel gravels are first met with descending Hunker creek above No. 6 pup. The occurrence here is small and the gravels although workable are comparatively low grade. Immediately below No. 6 pup is the famous Whisky hill. A short stretch of the old paystreak has been preserved at this point. The upper and richer portion of the hill has been hydrauliced completely away with a production variously estimated up to $2,000,000 and probably approximating $1,500,000. The lower portion of the hill is only partially worked out and still contains 199,400 cubic yards of workable gravels. The gravels are shallow, averaging about twenty-five feet in depth.

The gravels of the old channel are destroyed for some distance below Whisky hill, but appear again on the left limit on Delhi hill above Gold Bottom creek.

The Delhi Hill gravel area is comparatively small, measuring about 136,000 square yards. The gravels have an average depth of about twenty-five feet and a total volume of 1,121,080 cubic yards. The workable gravels are estimated at 869,450 cubic yards. The values are moderate except along the rim, where a few small fragments of the old paystreak were preserved. Some hydraulicing is being done on the hill with water brought from Upper Hunker creek, and a second ditch to a point on Gold Bottom creek is under construction.

Temperance hill immediately below Gold Bottom creek is covered by a triangular patch of gravel extending up Gold Bottom for a distance of 4,000 feet and down Hunker creek for 1,700 feet. The gravels are thin, seldom exceeding thirty feet, and averaging less than twenty-five feet in thickness. They are less compact than usual, and as a result of this most of the gold has settled down close to bedrock. The Temperance Hill gravels measure altogether 1,590,580 cubic yards, of which 788,750 cubic yards are considered to be workable.

Temperance hill has been a steady producer on a moderate scale since the early days of the camp, and is still of considerable economic importance. Some ground rivalling in richness that on the best Bonanza hills occurred along the rim at the junction of Gold Bottom and Hunker valleys. This is now largely worked out but portions of the hill still contain good values, occasionally exceeding 50 cents to the cubic yard. The back gravels as usual proved lean. Three small hydraulic plants operating with water obtained from tributaries of Gold Bottom creek are at work on the hill.

From Temperance hill down stream to Nugget hill above Hunker creek the central portion of the old high level channel, including the paystreak, has been destroyed. Portions of the rim gravels have been preserved at various points, some of which carry moderate values. An hydraulic plant has been installed to work two small areas below Bee gulch. These were estimated to contain 859,200 cubic yards of gravel.

At Nugget hill the paystreak of the old channel bends to the left and is again partly preserved. The upper part of the hill is lean but good values were obtained from the lower portions. The gravels are shallow, averaging about twenty-five feet in depth, and measure altogether 1,608,300 cubic yards. The workable gravels were estimated at 1,200,000 cubic yards. Nugget hill has been fairly well prospected but very little mining has been done on it owing to the difficulty of obtaining water. A small hydraulic plant is now in operation.

Summary of workable Gravels in Upper Hunker Hills.

Whisky hill	199,400	cu. yds.
Delhi hill	869,450	"
Temperance hill	788,750	"
Williams concession	859,200	"
Nugget hill	1,200,000	"
		"
	3,916,800	"

Estimated average grade, 25.2 cents per cu. yds.
Total valuation, $988,000.

Hill Gravels between Hester and Last Chance Creeks.

A wide band of White Channel gravel borders the left limit of Hunker creek continuously except when cut across by Eighty pup from Hester creek down to Last Chance creek, a distance of over two miles. The deposits of the old valley in this stretch were originally over a mile in

width in places. They have been partially destroyed as the present Hunker valley has been sunk through them. The preserved portion on the left limit has a width of from 800 to 3,000 feet, an average depth of about sixty feet, and contains altogether 25,850,000 cubic yards of material. A few small areas occur also on benches on the right limit but are unimportant.

The upper portion of the gravel area on the left limit from Hester creek down to Seventy pup is known as Paradise hill, and is the most important stretch of hill gravels on Hunker creek, with the possible exception of Dago hill.

The Paradise Hill gravel area has a length of 2,500 feet, and an average width of 1,500 feet. The gravels have an average depth of about sixty feet, and measure altogether, including the muck and slide material which cover them, on the back rim, 7,786,000 cubic yards. The workable gravels are estimated at 5,285,000 cubic yards.

The average grade proved somewhat difficult to determine on account of the exceedingly irregular distribution of the gold through the gravel and the absence of a satisfactory section across the paystreak. It is estimated at 23 cents per cubic yard, and the gold contents of the workable gravels at $1,215,500. This figure is based partly on mining returns and partly on a systematic sampling of all the available shafts and hydraulic cuts in the area. The best values occur in the upper part of the hill. Towards Seventy pup the gold diminishes both in quantity and coarseness.

Considerable mining, both by the drifting and hydraulic methods, has been done on Paradise hill, and two small hydraulic plants are now in operation.

The wide belt of White Channel gravels extending from Seventy pup to Eighty pup, a distance of 3,400 feet, is low grade everywhere so far as known. No definite paystreak has yet been located, although numerous shafts have been sunk for that purpose to bedrock throughout the area. The absence of a hill paystreak is somewhat remarkable as the bordering creek gravels are also lean, showing that it has not been destroyed. The gravels between the two pups have a depth in places of over a hundred feet and a total volume of 11,234,000 cubic yards. The gravels assumed to be workable include a small area below Seventy pup measuring 1,500,000 cubic yards, estimated at 13 cents per cubic yard, and portions of the rim gravels along Eighty pup. The latter are roughly estimated at 1,000,000 cubic yards, with a grade of 15 cents per

cubic yard. The probable production of the hill is estimated at $345,000. No mining has been done on the hill.

Preido hill between Eighty pup and Last Chance creek is also comparatively low grade as a whole, but contains some gravels carrying good values in coarse gold on the Last Chance slope. The Preido Hill gravels cover an area of 474,000 square yards, have a maximum depth of ninety feet, an average depth of forty-three feet and a total volume of 6,828,000 cubic yards.

The best values occur in a belt crossing the centre of the hill, 1,600 feet wide on the Last Chance slope and 1,100 feet on the Eighty Pup slope. Samples from shallow shafts and hydraulic cuts along the Last Chance rim indicated an average grade of 35 cents per square foot of bedrock. Those obtained from the Eighty Pup slope were much lower, averaging only 15 cents per square foot of bedrock. The zone defined above contains 3,093,530 cubic yards of gravel, estimated to average 15 cents per cubic yard, a total valuation of $464,000. This estimate is based on the assumption that the values obtained at the rims continue to the centre of the hill.

Summary of Values in Gravels between Hester and Last Chance Creeks.

	Workable Gravels. cu. yds.	Values. $
Paradise hill..................	5,285,000	$1,215,500
Hill between Seventy and Eighty pups....................	2,500,000	345,000
Preido hill.....................	3,093,530	464,000
	10,878,530	$2,024,500

Average grade, 18.6 cents per cubic yard.

Last Chance and Lower Hunker Creek White Channel Gravels.

Dago hill below the junction of Last Chance and Hunker creeks is covered by a large and important body of high level gravels. The gravel area deposit has a maximum depth of 100 feet, an average depth of 68.5 feet and covers a triangular shaped area 862,000 square yards in extent. The total volume of gravels on the hill measures 19,639,000 cubic yards.

Dago hill is crossed diagonally by a well defined coarse gold paystreak, 3,700 feet in length and from 300 to 500 feet in width. The workable

gravels have an estimated width of 600 feet (as the main paystreak is fringed with gravels carrying some values), and measure 6,423,000 cubic yards. The average grade calculated from the values obtained in sampling two sections across the paystreak is estimated at 19 cents per cubic yard.

In addition to the gravels on and bordering the main pay streak, portions of the rim gravels along Last Chance creek, roughly estimated at 750,000 cubic yards with a grade of 15 cents per yard, can probably be worked.

Total quantity of workable gravels, 7,173,000 cubic yards.
Estimated average grade, 18.6 cents per cubic yard.
Probable production, \$1,332,870.

Last Chance creek is bordered on the left limit for one and a third miles along Dago hill by a number of small areas of rich hill gravels. Considerable mining has been done on all the areas and a couple of them have been worked almost completely away. The two most important areas at present are Treasure and Discovery hills. These still contain 2,173,000 cubic yards of gravel, estimated to average 24.1 cents per yard. Probable production, \$524,000.

From Dago hill the White Channel deposit crosses the present Hunker valley to Australia hill, a small gravel-covered plateau separating Hunker creek from the Klondike river above their junction. The White Channel gravels on Australia hill cover an area of 1,586,000 square yards, have a thickness in places of over a hundred feet and a volume of 35,947,000 cubic yards. They are overlaid, as on Lovett hill at the mouth of Bonanza creek, by barren Klondike River gravels. The latter overlap the White Channel gravels on the Klondike River side. The portion resting on White Channel gravels has a thickness of 130 feet and a volume of 39,200,000 cubic yards.

Australia hill, although the largest both in extent and volume of gravels of all the Hunker hills, has so far proved of little economic importance. No definite paystreak crossing the hill has been located, and the chances are that none exist as the hill, apart from our own sampling, has been fairly well prospected. Coarse gold was found at one point near the mouth of Hattie gulch, and pay values are reported to have been found in a drift farther up the creek. The drift at the time of our visit was inaccessible. Samples from the rim near-by carried only light values. While some production may be expected from Hattie gulch, no definite statement in regard to the amount can be given. It is placed at \$150,000,

but this figure can only be regarded as a rough guess and may be largely exceeded.

Summary of Hunker Creek workable Hill Gravels.

	Volume. Cu. yds.	Values. $
Upper Hunker hills	3,916,800	988,000
Hills between Hester and Last Chance creek	10,878,500	2,024,500
Hills below Last Chance creek (exclusive of Australia hill)	9,346,000	1,856,870
Australia hill		150,000?
	24,141,300	$5,019,370

Estimated average grade (exclusive of Australia hill), 20.17 cents per cubic yard.

Total quantities of White Channel Gravels and overlying Klondike Gravels along Hunker Creek.

		cu. yds.
Small hills above Hester creek		5,378,600
Hills between Hester and Last Chance creeks		25,850,000
Dago hill		19,639,000
Last Chance hills		2,950,000
Australia hill	White Channel gravels	35,946,770
	Klondike River gravels	39,200,000
Small hills, not measured, estimated at		3,000,000
Total		131,964,370

Klondike River High Level Gravels.

High level gravels, usually at an elevation of from 200 to 300 feet above the valley flats, occur at various points along the Klondike river. These gravels differ altogether in character and appearance from the White Channel gravels of the creeks. The pebbles are smaller and more rounded, and consist mostly of slate, diorite and quartzite derived from the mountains of the Ogilvie range.

The Klondike River gravels as a rule carry only light values, but below the mouth of Bonanza creek they have been enriched and in places contain gold in commercial quantities.

The two most important areas of these gravels discovered so far occur on benches bordering the Klondike river at its mouth. These two areas contain approximately 4,780,000 cubic yards of gravel considered to be workable. The grade based on a somewhat hurried sampling of the various cuts and shafts is estimated at 20 cents per cubic yard. Probable production, $956 000.

General Summary of Probable Production of High Level Gravels.

	Volume of workable gravels. cu. yds.	Estimated Values. $
Bonanza creek..................	74,548,746	15,742,252
Hunker creek...................	24,141,300	5,019,370
Klondike river..................	4,780,000	956,000
	103,470,046	$21,717,622

Low Level Gravels.

The following estimates of the values remaining in the Klondike creeks are based mostly on data obtained from miners and others, as no satisfactory sampling of the creeks in addition to the hills in the time at our disposal was possible.

Eldorado Creek.

The rich paystreak in Eldorado creek, originally the richest in the district, has been pretty thoroughly worked, portions of it twice over. Experience in re-working claims has, however, shown that few if any were completely exhausted. This has proved to be the case not only in drifted claims but in those which were worked by the open cut method. The old tailings are also expected to yield a considerable sum when re-sluiced. The Eldorado paystreak has a length of about four miles and its production up to the present is estimated at $25,000,000. The probable future output is placed at $2,600,000, an average of $65,000 a claim.

Upper Bonanza Creek.

Upper Bonanza creek, the portion above Eldorado forks, proved rich up to Victoria gulch, a distance of about four miles. The paystreak in places rivalled that on Eldorado creek in richness, but the general

average grade was considerably lower. It has been less thoroughly worked on the whole and at the present time the claims probably average somewhat higher than those on Eldorado creek. The past production is estimated at $15,000,000 and the future at $3,225,000.

Lower Bonanza Creek.

Lower Bonanza creek has a length of about ten miles and is more or less auriferous throughout. The grade decreases as a rule down stream, but in an irregular manner, enrichments occurring at various points along the valley. Some of the claims a short distance below the forks proved very rich, and few unproductive claims occur from the forks down stream for seven miles. In the lower portion the valley flats increase in width, the gold is less concentrated and the gravels, except in a few places, have not been drifted. Preparations are now being made to dredge them and it is believed that there are few, if any, claims on the creek which cannot be profitably worked or reworked by this method.

The irregular grade of the Lower Bonanza Creek gravels has resulted in portions of the valley being well worked, while considerable stretches are still practically virgin and others are only partially worked. The production up to the present time, including that from the rich tributary gulches, is estimated at $11,000,000 and the future production at a minimum of $11,500,000.

Klondike River Flats.

The Klondike River flats are expected to produce largely in the future. The work of the past season has led to the belief that the high level White Channel gravels of Bonanza, Bear and Hunker creeks originally extended for considerable distances out over what is now the valley of the Klondike and were destroyed during its excavation and the gold contents scattered along the river flats. Rich gravels have been found in the Klondike River flats below the mouth of all these streams. Evidence was obtained indicating that the destroyed portion of the old Bonanza high level valley was at least a mile in length. The destroyed portion represents the extension of the Lovett Hill gravels and for some distance must have been equally as rich. Allowing for diminishing values down stream it is estimated that they contained gold to the value of at least $4,000,000 and possibly $5,000,000. The gold contents of the destroyed lower portions of the old valley gravels of Bear and Hunker creeks are roughly estimated at a minimum of $3,500,000.

Two dredges, one below the mouth of Bear creek and the other below the mouth of Bonanza creek, are at present working successfully on the Klondike River flats. The total production to date, partly obtained by dredging and partly by drifting and open cut work at the mouth of Bear creek, is estimated at $1,000,000.

Bear Creek.

Bear creek is comparatively low grade compared with Bonanza or Eldorado creeks, but contained some rich ground near its mouth. It is estimated to have produced gold to the value of $1,000,000 and the probable future production is placed at $600,000.

Hunker Creek.

The Hunker Creek gravels, like those of Lower Bonanza creek, varied greatly in grade along the valley.

A long, almost continuous, stretch of pay gravels extended from a point a short distance below Hester creek up stream for eight miles and occasional good claims have been worked for a further distance of two and a half miles. Most of the claims in the eight-mile stretch carried good values and some of them, especially around discovery claim and in the thirties and forties below, were very rich. They have all been more or less completely worked, mostly by the drifting method. Lean ground commences below Hester creek, and with the exception of three claims below the mouth of Seventy pup, and a short stretch near the mouth of Last Chance creek, continues down so far as known nearly to Dago pup, a distance of three miles. Portions of the mile stretch between Dago pup and the mouth of the creek proved very rich. These lower gravels are probably the richest on the creek at present as they have been less thoroughly worked than the once rich stretches above Hester creek.

The production of Hunker creek up to the present, including that from the tributaries Last Chance, Hester and Gold Bottom creeks, is estimated at $14,000,000, while the amount of recoverable gold remaining is placed roughly at $7,500,000. The data for this determination are more meagre than on the other creeks as little is known of the possibilities of the three mile lean and mostly unworked stretch above Dago pup. Light drifting values occur in places and it is probable that a considerable portion of it carries dredging values.

SUMMARY OF ESTIMATED VALUES IN LOW LEVEL GRAVELS.

Eldorado creek	$2,600,000
Upper Bonanza (above the Forks)	3,225,000
Lower Bonanza	11,500,000
Klondike River flats	6,500,000
Bear creek	600,000
Hunker creek (with tributaries)	7,500,000
	$31,925,000

GENERAL SUMMARY OF ESTIMATED PAST PRODUCTION AND PROBABLE FUTURE OUTPUT OF ELDORADO, BONANZA, BEAR AND HUNKER CREEKS AND THE KLONDIKE RIVER, HILL AND VALLEY GRAVELS.

	Estimated past production.	Estimated future output.
Eldorado creek	$25,000,000	$ 2,600,000
Upper Bonanza creek	15,500,000	3,225,000
Lower Bonanza creek	11,000,000	11,500,000
Klondike River flats	1,000,000	6,500,000
Bear creek	1,000,000	600,000
Hunker creek	14,000,000	7,500,000
	$67,500,000	$31,925,000
Upper Bonanza and Eldorado hills	24,000,000	8,213,532
Lower Bonanza hills	750,000	7,528,720
Klondike River Hill gravels	Small production.	956,000
Hunker Creek hills	2,500,000	5,019,370
	27,250,000	21,717,620
Creek values brought down	67,500,000	31,925,000
Totals	$94,750.000	$53,642,620

This estimate of the amount of recoverable gold remaining in the various Klondike creeks and benches is based, as stated previously, on sampling done by ourselves, on the results of actual mining operations and on information obtained from various miners, and is believed to be a reasonably close approximation. It, however, only represents present knowledge, and no allowance is made or can be made for fresh discoveries of rich spots, the day for which, as shown by a recent find on Hunker creek, is not altogether passed, notwithstanding the thorough manner in which the district has been explored. While it is unlikely that any large area of rich gravel has escaped detection minor discoveries may be expected as long as mining lasts and on this account any estimate is apt to be somewhat under rather than over the mark.

Indian River Creeks.

The estimate of values given above does not cover the whole of the Klondike district, as the creeks on the Indian River slope, including such important producers as Dominion, Gold Run, Sulphur and Quartz creeks, were not examined. These streams are estimated to have produced gold to the value of $24,250,000, making the total production of the camp to date $119,000,000. They have not been worked, on the whole, as thoroughly as the Klondike creeks, and the percentage of unmined gold is probably somewhat higher. A production of from eight to ten million dollars may still be expected from them.

The production of the Indian River creeks has been obtained mostly from the low level creek gravels. Bench gravels carrying good values occur at some points, notably along the central portions of Dominion and Quartz creeks, but their total yield has been relatively small.

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GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DEPUTY HEAD AND DIRECTOR

PRELIMINARY REPORT

ON A PART

OF THE

SIMILKAMEEN DISTRICT

BRITISH COLUMBIA

BY

CHARLES CAMSELL.

OTTAWA:

GOVERNMENT PRINTING BUREAU

1617 1907

No 986

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GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DEPUTY HEAD AND DIRECTOR

no. 6

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ON A PART

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BY

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OTTAWA:

GOVERNMENT PRINTING BUREAU

1617 1907

No 986

A. P. Low, Esq.,

Director Geological Survey of Canada.

DEAR SIR,—Herewith I beg to submit a preliminary report of my investigations in the Similkameen mining district of southern British Columbia carried out during the season of 1906. A topographic map, geologically coloured, of a portion of the district, accompanies the report.

My acknowledgments are due to many of the prospectors and claim owners in the district for much courtesy and kindness, some of whom willingly gave up their time to conduct the party over particular sections of country that they knew well, and which would have entailed considerable loss of time to us to have examined unaided. Mr. E. Waterman, resident manager of the Vermilion Forks Mining and Development Company at Princeton, very kindly supplied me with copies of the records of the various bore holes that have been drilled in the Tertiary coal basin. Mr. C. F. Law and Mr. Emil Voigt supplied me with much information on the history and development of the respective areas that they are interested in, on Bear creek and Copper mountain respectively. Mr. J. W. Waterman of Okanagan Falls was good enough to give me a detailed account of the several hydraulic ventures exploited in the Similkameen and Tulameen districts commencing from the year 1893. To these gentlemen I wish to express my thanks for their generous assistance.

I remain, sir,

Your obedient servant,

CHARLES CAMSELL.

OTTAWA, April, 1907.

CONTENTS.

PRELIMINARY REPORT.

SUMMARY OF OPERATIONS.

My instructions for the season were, to commence a topographical and geological survey of the Similkameen district of southern British Columbia, the object being to carry out for this district what has already been done for West Kootenay by Messrs. Brock and Boyd of this Department, namely, the publication of a map on a scale of four miles to the inch with a contour interval of two hundred feet. This sheet, which will be called the Similkameen sheet, will cover an area of about 3,500 square miles, and will embrace the mining camps of Bear creek, Granite creek, Copper mountain, Roche river, Hedley, Ollala and Fairview, including the country from the Okanagan valley to the Hope mountains, and from the International Boundary northward for a distance of about forty-five miles.

A work of this magnitude must of necessity occupy the attention of any field party for several seasons, but as certain sections of this area are economically of far greater importance than others I was instructed to confine the work of the first seasons to the more accessible and more developed portions of the district, leaving the remainder for a later date.

Princeton, the most central point for the region selected, was chosen as the headquarters for the season, and except for a hurried reconnaissance, at the end of the season, of the important camp of Bear creek on the Tulameen river, all the work was confined to a belt about eight miles wide lying between this place and the International Boundary. This belt, which covers an area of about 250 square miles, is the subject of this report and will be referred to as the South Similkameen district.

Though the early part of the season was very wet, no rain fell from the end of June until the beginning of September, so that the forest fires, which started in July, remained unchecked for several weeks, during which the pall of smoke rendered it impossible to carry on triangulation. For this reason the original intention of extending the topographic map up the Tulameen river had to be abandoned.

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Transport of supplies was effected by means of pack horses obtained at Penticton. The party consisted of four and included Mr. J. A. Allan, assistant, and two men.

TOPOGRAPHICAL AND GEOLOGICAL WORK.

The topographic work consisted of a skeleton transit triangulation begun on the International Boundary Line, where it crosses the Pasayton river, and carried down the Similkameen river to Princeton, taking in a belt about eight miles wide. Two monuments on the Boundary Line furnished an excellent base for the commencement of the triangulation. As the whole belt south of Whipsaw creek is only traversed by one main trail, and the bordering country is very rough and heavily timbered, many traverses and stations necessary for a more complete survey had to be abandoned. An area of about 120 square miles, embracing the mineralized areas of Copper mountain, Kennedy mountain and the Princeton coal-basin, was surveyed in greater detail, and the position of this sheet was fixed on the skeleton triangulation. A map of the surveyed mineral claims and land preemptions compiled by the Lands and Works Department in Victoria was used as a base on which to plot the contour lines and other features of the topography. Elevations were obtained by aneroid, and referred to the levels carried through from Spence Bridge by the Canadian Pacific Railway Company in their survey of a location line down the Similkameen river. The elevation of the bridge across One-mile creek near its mouth was taken as the datum, and is reckoned at 2,000 feet above sea level. A geological and topographical map of this area on a scale of half a mile to the inch, with a contour interval of 100 feet, has been compiled.

By far the greater part of the geological work is confined to the mineralized sections of the belt, viz.: the Roche River camp, Copper and Kennedy mountains and the Tertiary coal-basin. These were done in some detail, while the work on the remainder of the country was only such as could be done in connexion with the topography on a hurried trip to and from the Boundary Line. The pack trail from Princeton to the Boundary Line follows the western side of the Similkameen river nearly all the way, and as one can only ford this stream in extremely low water a long strip of several miles south of Combination camp on the east side of the river was not examined at all, and is only conjectured to be covered by recent volcanic rocks.

Fossils occur only at the north end of the belt in the Tertiary sediments, and at the south end in an area of Cretaceous rocks, so that it has been found impossible to refer the rocks occurring in the central portion to any definite period of time. The greater part of this area is covered by recent volcanic flows, which are later than the Tertiary sediments.

In the Copper Mountain district, where a large batholithic mass of monzonite has invaded a series of metamorphosed sedimentary rocks, the two varieties of rocks have been grouped on the map under one geological colour, though the two are of widely different age. The reason for doing this is that it has been found impossible to separate them completely in the field. Except in the cañon of the Similkameen river, and where some development work has been done on the claims, outcrops of rock are not common and the igneous rock holds many isolated areas of the sedimentary rocks as inclusions in its body, and their boundaries were impossible to determine. To add to the complexity the whole mountain is cut by a great many dikes of varying composition, besides being traversed by many slips and faults along which alteration has taken place. These, coupled with the widespread mineralization, have wrought such profound changes in the rocks that it is now difficult in many cases to say what their original composition might have been.

A majority of the claims were visited and examined, but owing to the absence of many of the prospectors, who might have acted as guides in the district, some were unavoidably passed over. On few of these, however, has development work been carried to a depth of forty feet, and a majority of them have not been prospected below the level of surface oxidation. Consequently, many of the geological problems here encountered must remain unsolved for the present, or until such time as development work has progressed much further and the camp has reached the producing stage.

After completing the work on Copper mountain, and defining the Tertiary coal-basin, a short time was spent in a geological reconnaissance of Bear Creek camp and the platinum belt of rocks on the Tulameen river above Otter Flat. The importance of this field is such that with the short time at my disposal at the end of the season it was decided not to go into detail in any one section, but to go roughly over the whole ground with the view of making a more detailed survey in the near future.

SITUATION, ETC.

The town of Princeton, which was the base of operations for the season, lies in the angle formed by the junction of the Tulameen river with the South Fork of the Similkameen river, and is thirty-one and a half miles in a direct line north of the International Boundary Line. The nearest point from here to which one can buy a railway ticket is Penticton at the south end of Okanagan lake. Penticton is joined to Princeton by seventy-five miles of good wagon road, over which a bi-weekly stage is operated. Princeton can also be reached from Spence's bridge on the main line of the Canadian Pacific railway. This latter route is about one hundred and twenty-five miles long, but has recently been shortened by the building of a branch line from Spences Bridge to Nicola lake, forty-five miles in length. A third route by which Princeton can be reached is over the old Hope trail across the mountains from Hope. Hope is distant about sixty-five miles, and the trail is merely a pack trail, which is not being much used at the present time, and is consequently not kept in very good repair. This route is only used in the summer time from May to October, as the high altitude of the summit and the depth of snow make the trail impassable for horses during the winter months.

Two separate lines of railway are projected and being built into the district. The Victoria, Vancouver and Eastern railway is being carried through from Midway up the Similkameen river and will eventually be extended through the Hope mountains and connected with Vancouver. It is expected that the line will be built through to Princeton in the summer of 1907. The Canadian Pacific railway has also had preliminary surveys made of a line southward from Nicola lake to Princeton and down through the valley of the Similkameen river. This will be an extension of the section of road already built through to Nicola lake and connected with the main line at Spences Bridge. The prospect of either or both of these railways passing through the country has brought the Similkameen district more before the notice of investors and capitalists and given a certain impetus to claim owners and prospectors, which comes as a relief after the dullness of the few preceding seasons. The country has many natural resources that have not been developed only on account of the lack of cheap transportation, and no future railway company need fear a scarcity of freight.

At present the Similkameen district above Hedley is only traversed by one trunk wagon road, which follows the valley of

the river up to Otter Flat and then strikes northward to Nicola lake. From Princeton, a few short branches to run Whipsaw creek, Copper mountain and northward up One-mile creek; while from Otter Flat another branch, twelve miles in length, leads up to the mineral claims at the head of Bear creek. Over the rest of the district only a few pack trails lead to different points, such as the Hope trail, the Boundary trails up the Roche and Pasayton rivers, and a few others that have been opened up by prospectors owning claims in the mineralized areas that they lead to. The trail to the Boundary Line from Princeton was the most useful one to us, as it runs directly through the belt reported on from north to south. This leaves the Hope trail, near the mouth of Nine-mile creek, and ascending the steep hillside, south of Whipsaw creek, follows the trend of the river at an elevation of about fifteen hundred feet above it, and at a distance of a mile to a mile and a half back from it. It only descends to the river at the mouth of Copper creek, leaving it again to cut off the wide bend occurring between this and the mouth of the Pasayton river. At the mouth of the Pasayton the trail branches, each branch to cross the Boundary Line at different points, the one following the valley of the Pasayton and the other that of the Roche river.

Where there are no trails the ridges and summits of the hills are often open enough to afford easy travelling on horseback; but all the valleys and lower elevations in the belt surveyed are so heavily timbered that it is often impossible to get through with a pack-horse, and even difficult on foot without first cutting a trail.

CLIMATE.

The climate of the Similkameen district about Princeton is an exceedingly pleasant one. Lying on the eastern side of the Hope mountains, which catch much of the moisture drifting eastward from the Pacific, it occupies part of the interior dry belt of southern British Columbia. The rainfall is very light, and irrigation is necessary in the latter part of the summer wherever farming is carried on. The extreme upward limit of agriculture is slightly over three thousand feet above sea level, and as the greater proportion of country lies above this level it will be readily understood that the amount of cultivable land is not very large, and is confined to the lower benches of the valleys and to the Tertiary depression about the town of Princeton. Above this level, too, the plateau is subject to more or less severe

summer frosts, and even in the lower levels of the district only the months of July and August can be counted on with any degree of certainty to be free from frosts. The soil is everywhere very good and yields excellent crops. Some wheat and other cereals are grown, but the most of the farmers are content merely with the production of vegetables for their own and for local consumption. Small fruits, such as strawberries, raspberries, currants and gooseberries are easily cultivated. Mr. Hunter has also successfully grown apples, and is experimenting in plums, cherries and pears, but the pear trees are still too small to judge whether they will be successful or not. Farther down the valley the climatic conditions become more suitable for fruit-raising, and at Keremeos all these fruits, as well as grapes, are grown successfully.

Stock-raising is carried on to a certain extent, but the winters are too severe and the area of land on which cattle could feed too limited to make this industry very general.

I am indebted to Mr. Hugh Hunter, mining recorder at Princeton, for the following notes on meteorology for the year 1904:—

Mean summer temperature............	67.96°	
Mean winter temperature, December to March............................	33.23°	
Highest temperature..................	101°	Aug. 4th.
Lowest temperature..................	—27°	Feb. 9th.

Precipitation—

Rain..............................	7.7 inches.
Snow..............................	65 "
First snowfall to remain...............	Dec. 19th, 1903.
Snow disappears from valleys..........	April 13th, 1904.

History and Development.

Placers.—Ever since the year 1860, when placer gold was first discovered on the Similkameen river, above Princeton, by a government prospecting party under Mr. Allison, mining and prospecting has been going on continuously to a greater or less extent up to the present time. A year or two after this discovery most of the white miners who were working on this stream and the Tulameen river were drawn away to the Cariboo country by the great excitement following the discovery of Williams and Lightning creeks, and only a few Chinese were left. These continued to work the old localities without making

any attempt to discover new ones until the early eighties, when a number of white miners returned, and an increased activity was manifested in prospecting, both for placers, as well as for lode minerals. The discovery of coarse gold on Granite creek, in 1885, caused considerable excitement and resulted in the biggest rush in the same year that the Similkameen has ever seen. Other discoveries higher up the Tulameen quickly followed, and the maximum output was probably reached in 1886, the figures given for that year in the report of the Minister of Mines being $203,000. On the southern portion of the river, though placer gold is found as far as the Roche river, the most productive bars were found below the mouth of Whipsaw creek, on Whipsaw creek itself and on Nine-mile, a tributary of the latter heading near Granite creek. These bars have now been worked out and no placer mining has been attempted on them for several years.

The most interesting feature that has been developed in connexion with placer mining on the southern portion of the Similkameen river and Tulameen river, is the occurrence everywhere of platinum in association with the gold, and indeed this district has proved to be the most productive of that mineral that has yet been discovered on the North American continent. Dr. Dawson has estimated that from 1,400 to 2,000 ounces of platinum were obtained in the district in 1887 at a time when placer mining was at its height, and previous to that it was not considered worth while saving in the clean up. At the present time placer mining is confined to Granite creek and the upper part of the Tulameen river, and is carried on by only a few whites and some Chinamen. The annual output of platinum has now decreased to not more than forty to fifty ounces. Owing to the enormous rise in the price of platinum, however, it is altogether likely that in the ensuing year some attempts will be made by interested parties to work some of the higher bench deposits of gravel which are known to carry platinum, but which necessitated too large an outlay of capital to have been worked before.

Lode mining.—Coincident with the increase of activity in placer mining in the early eighties was corresponding interest in the search for the source of these placers in the rock. Copper ore, carrying some values in gold and silver, was discovered at the mouth of Friday creek, and also on the opposite side of the Similkameen, on what is now known as Copper mountain. Two claims staked by Mr. Allison in 1887 on the side of the valley opposite the mouth of Friday creek were Crown granted, and a

good deal of prospecting by tunnelling was done. Apparently the results obtained did not justify the continuation of the work, and the ore being too low-grade to pay the claims were abandoned shortly after. On Friday creek, however, some prospecting and development work has been carried on almost continuously since the year 1887 up to the present time. One of the first claims located—the Victoria—situated about 400 yards up the creek from its mouth, was more developed than any other, and some pockets of beautiful bornite ore discovered. This was found to be of such a high grade that some of it was carried out on pack-horses and shipped to a smelter. This claim is still being held under the name of the Gladstone, but the work done on it is only such assessment as is necessary to prevent it from lapsing.

On Copper mountain itself the best known claim, and, with the exception of the two staked by Mr. Allison, in 1887, the earliest one recorded, is the Sunset. Though copper ore was known and discovered in this neighbourhood by Jameson, in 1888, while trapping in these mountains, no claims were taken up until the discovery was reported to R. A. Brown. Brown staked the Sunset claim, but the claim lapsed and was restaked again in 1896, and in this year the first assessment work was done on it. The following year some ten or a dozen claims were staked, mostly adjoining the Sunset, and in 1898 options were taken on some of these by eastern capitalists. These men, however, were discouraged by the difficulties of transportation and allowed the properties to drop.

In 1898 and 1899 there was a great influx of prospectors to this district, and the Tulameen and the remaining areas of Copper mountain, Kennedy mountain, Friday creek and Combination camp were staked. Voigt's camp, on Wolf creek, was also located at this time. From 1898 to 1900 interest in Copper mountain and neighbouring properties was keen, and much money was expended in prospecting different claims. Options were given on several claims around, including the Sunset, to eastern capitalists, but owing to differences with the claim owners and for other reasons the options were again dropped. At the same time the old Copper Mountain wagon road was built by several of the claim owners.

After 1900 very little work, outside of the necessary assessment work, was done until 1905. At Voigt's camp, however, a few men were kept steadily at work on the claims, and in 1904 the present wagon road from Princeton was built by Mr. Voigt, with some assistance from the government.

In 1905 the British Columbia Copper Company took options on ten or twelve claims around and including the Sunset, and work was carried on for about eleven months. A diamond drill was brought in and much deep drilling done, but the results were not made known to the public.

Hydraulic mining.—In 1893 some prospecting and surveying was done on the east side of the Similkameen river, above Princeton, by parties associated with W. C. McDougald, with a view to working some of the benches stretching back from the river by hydraulic methods. Gold was found in all the test pits, but the bed rock was not sufficiently high above the level of the stream to afford a good dump. This, with the fact that a ditch, seven miles in length, to carry water from the Similkameen river on to the ground, would only give a head of 116 feet, forced the promoters to abandon their project.

In 1895 the Anglo-American Company was formed by Captain S. T. Scott, with the object of working some ground situated on the west side of the Similkameen river, just above the mouth of Whipsaw creek. A ditch two miles in length brought water from Whipsaw creek, and under a head of 320 feet this was supplied to two No. 5 Monitors at the foot of the bench. Sluicing was carried on for a period of eight days, when it was found that the bedrock here also was too low to afford a dump for the tailings, and they were constantly blocking the channel and forcing the water back over the flat. The expense of keeping the sluice boxes free from the tailings, and the fact that bedrock was not reached in the pit, caused the company to abandon the work and go into liquidation.

The most successful attempt at hydraulicing was that undertaken by Mr. W. J. Waterman in 1895 on some ground about three miles south of Princeton. This ground had formerly yielded from $5.00 to $10.00 to the hand, and had been worked both by whites and Chinese. Water was obtained from a spring and stored in a reservoir immediately above the bench to be worked. A self acting gate to the reservoir was built with the intention of using the water as a bucking hydraulic. The water was stored at night behind an old beaver dam above the reserviot, and during the day was allowed to run into the reservoir which it filled two or three times an hour. The gate acted automatically and let out a head of about 2,000 miners inches for seven or eight minutes. When the reservoir was empty the gate closed, and the boulders, etc., in the pit were cleared up and the ground got ready for the next run. In November, 1895, a partial clean up gave results of from twenty-five to thirty-five cents per cubic yard of ground moved

and paid expenses. The next year the property was sold to the Vermilion Forks Mining and Development Co. More water was brought from Stevenson creek and a small monitor installed under a hundred foot head. Two runs were made in 1898 and the results obtained gave ten to fifteen cents per cubic yard of ground moved. The amount of water was not sufficient to move the heavy wash, and trial surveys were run to bring more water from Nine-mile creek. The amount of workable ground, however, was not large enough to warrant the expense of such a ditch and the work was dropped.

The river bars at the mouth of Friday creek fifteen miles above Princeton were at one time found to be very rich. Here a trial pit was also opened up. A ditch one-half mile in length was dug and a short pipe line with a monitor installed. Work was carried on for a part of one season and in the next spring when operations were about to be commenced it was found that the whole ditch system had been washed away into the stream. The claims were then abandoned and have lain idle ever since.

On the Tulameen river the earliest attempt at hydraulicing was made by a group of Vancouver men who built a flume and ditch from Eagle creek with the intention of recovering the platinum from a bench a short distance below this point. The bench was small and was soon washed out, with what results was not ascertained.

On Granite creek, from which probably more placer gold was recovered than any other part of the Similkameen district, some bench claims were opened up by Captain Scott, Robert Stevenson, W. E. Hogg and others. A flume four miles in length was laid and work began on the Swan claim and at its upper end. The gold here is very coarse and probably much was recovered, but the company shortly after went into liquidation and the court is said to have cleaned up about $900.00 from the sluice boxes. Mr. Hogg afterwards worked a small pit four miles below the mouth of Granite creek and washed out the gravel from an old high channel of the Tulameen river. It is believed to have paid for the season, but the pit was filled up with wash from the mountain side the next spring, and never reopened.

Drilling.—Boring operations for lignite began in 1901, and have been prosecuted by several parties interested in the development of the Princeton coal basin. The Vermilion Forks Mining and Development Company is the largest holder of coal claims and it has sunk six bore holes to test its properties. Two others have been sunk by Blakemore and one by Sharp; and with the

exception of Sharp's bore hole all have been sunk in the valley of the South Similkameen river between Princeton and Ashnola.

PREVIOUS GEOLOGICAL WORK.

The first geological work done on the southern portion of the Similkameen of which we have any record is that of Mr. H. Bauerman the Geologist to the North American Boundary Commission. This work was done in the years 1859 to 1861 at the time the Boundary Line was first being defined, but although a report had been prepared by Mr. Bauerman it was never printed until done so by the Geological Survey Department in 1884, with the permission of the author. In this survey Mr. Bauerman crossed the belt now being reported on by two routes. His northern route was by the old Hope trail, entering the belt by Whipsaw creek and following down the valley of the Similkameen river. His southern route lay down the valley of the Roche river to the mouth of the Pasayton, from which point he struck across the divide to the Ashnola river by a trail long since abandoned. His work was of a preliminary character, and he makes no mention whatever to lode minerals of economic value occurring in the belt, and refers only briefly to the placer mining on the southern portion of the Similkameen that was at that time carried on by Chinamen, and to the occurrence of lignite beds on the Tulameen river.

In 1877 Dr. G. M. Dawson spent the season in a geological exploration of the southern interior of British Columbia, and one of the routes followed, viz., the Hope trail, took him through the Tertiary basin about Princeton and down the Similkameen river, on precisely the same course as that followed by Mr. Bauerman. A detailed report of his observations is found in the Report of Progress, 1877-78. Owing to the discoveries of rich placers in 1885 on Granite creek and the Tulameen river Dr. Dawson again visited the district in 1888, but in the short summary which appears in the Annual Report of that year he deals entirely with the Tulameen river and its tributaries. This was the last survey made by the Geological Survey Department until the work of this year.

In 1901 Mr. Robertson, Provincial Mineralogist for British Columbia, examined and reported on the Princeton and Copper Mountain district, and went as far up as the head of one of the branches of the Roche river. Mr. Robertson's observations were confined entirely to the mineral claims in the different camps,

and he makes no reference to the general geology of the district.

In 1901, the International Boundary Commission Survey commenced the construction of a topographic map of a five mile belt lying along the Boundary Line. Dr. R. A. Daly was attached to this as Canadian geologist to the commission, and his observations, extending over this belt, have added much to our knowledge of the geology of the southern border of the Similkameen district. Using the topographic map so constructed as a base the boundaries of the different geological formations met with have been accurately sketched in and other geological data added.

PHYSIOGRAPHY.

The South Similkameen district lies in a part of what has been called by Dr. G. M. Dawson the great interior plateau of British Columbia. In the southern part of the Similkameen district, however, it partially loses the chief characteristics of a plateau, which are so well exemplified in the region to the north of this district, and which gave the author of the name the reasons for calling it such, and it here becomes gradually more mountainous, until it finally merges into the high rugged and snow-covered peaks of the Cascade range to the south of the International Boundary Line. In the northern part of the belt surveyed, and in the country to the north of the Similkameen and Tulameen rivers, the plateau features become more pronounced and the ruggedness of a mountain region is lost. In looking southward over it towards the Nicola lake from some of the higher points the eye appears to travel over a gently undulating surface showing a succession of rounded and generally wooded hills, and nowhere any sharp and rugged peaks or any banks of snow.

Above Princeton the southern portion of the Similkameen river flows in an almost north and south course until it forks some twenty-five miles south of here. The main branch or Pasayton river continues in the same course up to and across the Boundary Line, while the west branch or Roche river comes from the southwest. The name Roche river was originally only applied to a small branch of this stream flowing into it from the south about twelve miles above the mouth of the Pasayton, but in recent years it has become customary to refer to this larger stream as the Roche river, while in reality it should retain its original name of South Similkameen.*

The valley of the Roche river is wide and flat, and filled with gravel and wash, which frequently forms terraces on either side

*The Geographic Board, however, have decided that the South Similkameen shall be called the 'Similkameen'—Ed.

of the river. These terraces are often cut through by the stream, forming steep cut banks of fifty or one hundred feet in height. The gradient of the stream is comparatively low, and the sides of the valley generally slope back easily to a height of about 2,000 feet above the river. The Pasayton river, however, occupies a much narrower valley and the stream is much more rapid.

About a mile below the junction of the two streams the southern portion of the Similkameen river enters a deep and narrow cañon, through which it flows for a distance of about eighteen miles, or as far as the mouth of Whipsaw creek. The gradient of this part of the stream is very steep, being at least forty feet to the mile and very probably more. As the lower portions of the valley are usually very precipitous and carved out of the solid rock, gravel benches rarely occur, and it is seldom possible for wash to find any lodgment on its sides The bed of the stream is filled with large boulders, rounded as well as angular, and for these several reasons it is impossible to ford this section of the stream except in the late summer when the water is very low.

Below the mouth of Whipsaw creek the stream enters the low, shallow Tertiary coal basin, and the change in character is very abrupt. Here the grade becomes slightly easier though still very steep, and the banks of the valley are usually composed of unconsolidated material, and only occasionally are there exposed sections of the lignite-bearing measures.

The tributaries of the southern portion of the Similkameen river are few and insignificant, the most important being Whipsaw creek and Copper creek, both flowing in from the west, and each entering the main stream by deep and narrow valleys. The former heads with one of the branches of the Skagit, and its valley is followed from one end to the other by the old trail from Hope to Princeton.

Both the Roche and the Pasayton rivers draw their waters from the high range of mountains lying on and to the south of the International Boundary Line, their branches interlocking with those of the Skagit drainage and the Methow, the latter flowing directly southward into the Columbia river.

The basin occupied by these two streams is enclosed between two forks of the Cascade range of mountains, which, running up northward through the State of Washington, divides just south of the Boundary Line. The western or true Cascades, or Hozameen range, forms the divide between the Roche and Skagit rivers, and runs up northward to the west of the Tulameen, and is there locally known as the Hope mountains; while the eastern Cascades

or Okanagan range strikes slightly east of north and lies to the west of the Pasayton and Ashnola rivers. The western of these two forks is the more persistent and stronger range, and its summits show very little diminution in elevation or ruggedness of relief beyond the limits of the Similkameen sheet to the north. The eastern fork, however, is not so persistent or well defined. Its summits at the Boundary Line sometimes attain an elevation of 8,500 feet, but these gradually dwindle down, until north of the Similkameen river its highest points are little more than 7,000 feet and the whole range gradually sinks into and becomes a part of the great Interior plateau.

The elevation of the town of Princeton, as deduced from instrumental levels carried through from Spokane by the engineers of the Victoria, Vancouver and Eastern railway is 2,120 above sea level, while that of the townsite of Allison two miles below is given as 1,978 feet by levels carried from Spences Bridge by Canadian Pacific Railway engineers. There appears to be a discrepancy here, and a difference of about 100 feet between the levels of the two railway surveys. The levels of the Canadian Pacific Railway survey were used in obtaining the elevations for the topographic map.

Taking Princeton, which lies in a shallow depression occupied by Tertiary sedimentary rocks, as the central point in the curve formed by the two forks of the Cascade range of mountains, there is a marked rise in slope of the lines radiating to the west, south and east, while the gradient to the north is almost imperceptible. In this curve the hills have all been worn down below the limit of intense alpine erosion, and now appear as rounded ridges and dome-shaped summits of gradually increasing elevation towards the circumference. Only towards the circumference of this curve do the summits attain an elevation greater than the tree line, which in this district is approximately 7,000 feet above sea level, but with the exception of the immediate vicinity of Princeton these are usually well wooded with spruce, pine, balsam, and tamarac. This rounded outline and regularity of form, while in the main due to erosion, is also in part the result of the filling in of old irregularities of the surface by the Tertiary lava flows which still cover such a large proportion of the surface of the belt. Glacial action, both the action of erosion as well as that of deposition, has a'so been instrumental in reducing the vertical relief.

Many evidences of recent development in the topography occur. The southern portion of the Similkameen river from the Pasayton to the mouth of Whipsaw creek occupies a deep,

narrow V-shaped valley indicative of a comparatively recent uplift, which imparts to this portion of the stream increased vigour and power of erosion. The valley of the Tulameen river too, above Otter creek, as well as many of its tributaries, is very narrow and steep, showing that the drainage has not been very long in operation since the change in elevation.

Numbers of terraces and deposits of gravel also occur at various elevations on the sides of the valleys to a height of 3,400 feet above sea level. The higher ones of these appear to have been formed when the whole valley was filled with water up to these levels, while others nearer the river and lower are the result of the action of the present streams in cutting down their beds. As a rule the higher ones only now occur as small remnants of once more extensive terraces, formed in the period immediately following on the disappearance of the Cordilleran glacier, and which have since been reduced in size by the ordinary atmospheric agencies of erosion. These are the most apparent evidences of comparatively recent changes of level.

Accompanying these changes of level, and either a direct result of them or of the blocking of ancient channels by recent volcanic flows, have been some striking changes of drainage. The most marked instance of this is the deep valley of Smelter lake and Wolf creek, now occupied by a stream inconsistent with the size of the valley. It seems probable that this valley of Wolf creek with its continuation through Smelter lake once carried a great part of the drainage of the southern portion of the Similkameen river, but that the filling up of parts of its channel by recent volcanic flows, or the same uplift which caused the southern portion of the Similkameen river to cut its deep cañon, also forced the stream into its present roundabout course through the Tertiary basin about Princeton. All the streams entering this valley from the south, above and including the Coldwater river itself, occupy hanging valleys, so that they debouch in waterfalls or have been forced to cut deep cañons down to the level of the trunk valley.

Glaciation.

During the glacial period the great Cordilleran glacier covered all the summits north of the Boundary Line in this belt. The conditions we now find existing as a result of this glaciation tend to show that the glacier was losing its great power of erosion, and was rather depositing its load of débris. This is evidenced by the small number of grooved and striated rock exposures and "roches

moutonnees," and by the thick and widespread deposit of rock detritus on the summits of the hills as well as in the valleys. Some striae were noted on the southern part of the belt on the upper slopes of the Pasayton and Similkameen valleys, but these are practically valueless as an indication of the general trend of the main body of the ice, for the direction of flow would here be entirely influenced by the course of the valley. All striae noted were found to conform to this course. On a wider area and one traversed by valleys running in a diversity of directions, such as that covered by the Kamloops map sheet of Dr. Dawson, the average of many readings obtained on points that are uninfluenced by nearness to any great valleys would give very nearly the course of the upper portion of the ice sheet; but as the sheet now being reported on lies entirely in the valley of the southern portion of the Similkameen river and its tributaries, all striations would be more or less influenced by this valley, particularly as the trend of the valley only diverges a few degrees from what has been reckoned to be the general trend of the ice sheet over the Interior Plateau.

By far the greater proportion of drift is unmodified material derived from the breaking down of rocks within a short distance of where it now lies. This drift is so widespread that it is usually only where it has been cut into and washed away by streams that exposures of the solid rock can be found. It also imparts to the topography an appearance of fairly mature erosion, giving to the hills in the belt a rounded and graded outline which is so characteristic a feature of the whole Interior Plateau.

Prospecting for mineral deposits becomes, on account of the mantle of drift, more difficult here than in a region where the strength of glacial erosion had been greater. The heavy growth of timber too adds to the difficulties. The tree line in this belt is approximately 7,000 feet above sea level, and as it is only a few points in the southern portion that exceed this elevation, it will be seen that the area of surface covered by timber far exceeds that which is devoid of it.

Agricultural land.

Stratified deposits of sand and clay are cut into and exposed a short distance below the mouth of the Roche river. These appear to have been laid down in still water along the southern face of a northward retreating glacier. The water derived from the melting of the glacier probably for a while discharged southward across the divide into the Skagit river, but after this had been suffici-

ently lowered to prevent an outlet in this direction a lake was formed in which these beds of clay and sand were deposited. On the still further retreat of the glacier this water would probably find an outlet northward and eastward down the valley of the Similkameen river. Terraces of gravel and sand whose origin is probably contemporaneous with the deposition of these stratified deposits, and which were formed along the shores of such lakes, are frequently found adhering to the sides of the main valley at elevations above that of the stratified deposits. Other terraces, which occur at lower elevations farther northward, of undoubted lake origin, were formed when the water had subsided still lower.

The White Silt deposits, which are so well shown on Okanagan lake, and which mark a period near the final disappearance of the glacier, are not represented in the district, though the lowest depression in the belt, 2,000 feet above sea level, is well below the highest level at which these deposits are found in other parts.

Hanging valleys have already been referred to as occurring on the valley of Wolf creek and on the upper part of the Tulameen river, but whether these can be attributed to glacial action or to a quite recent uplift and tilting of certain sections, it is at the present time impossible to say.

The thick covering of glacial drift, though somewhat of a hindrance to the speedy development of the mineral resources of the district, must be reckoned as one of its assets in that it has produced a considerable extent of excellent farm and grazing land. The open, rolling hills all around the town of Princeton are covered with beautiful bunch grass, and support herds of cattle and horses throughout the summer season. At present the cultivation of farm land is almost entirely confined to the flats of the Similkameen and Tulameen rivers and their tributaries. A few pre-emptions have been taken up on the higher slopes of the valleys where the surface is not too steep, but the limit at which farming is carried on can be put at 3,200 feet above sea level. Below this level is a good deal of land yet untouched, which could support a much larger population than the country now holds.

SOLID GEOLOGY.

Though much that follows has already been fully dealt with in the Director's Summary Report for 1906, it must be repeated here; but a change hos been made in the form of classification and also in the naming of the igneous rock of Copper

mountain. Both of these were necessitated after a microscopic study of the numerous rock samples collected in the district.

Geological work on the southern portion of the Similkameen becomes very difficult on account of the great variety and complexity of the rock formations, as also on account of the thickness and widespread covering of drift. Plutonic, volcanic and sedimentary rocks are all present, covering a period from Palæozoic to later Tertiary times. Fossils occur in the Tertiary lignite basin, about Princeton, and also in the Cretaceous sandstones of the Roche river, but the remaining sedimentary rocks—limestone, argillite and quartzite—are either unfossiliferous or have been so badly crushed as to destroy any remnant of animal life that they ever contained. Contacts between the igneous and sedimentary rocks are rarely exposed, so that it is difficult and very often impossible to establish geological relations. Added to this is the difficulty in the southern half of the belt of travelling anywhere except on trails that have been cut by prospectors through the bush. This latter difficulty, however, does not hold in the northern half, where one can usually obtain access to any part, whether there is a trail or not.

The formations met with and their approximate or relative ages, are as follows:—

(1) *Glacial and recent deposits.*

(2) *Post Oligocene*—
Volcanic, consisting of andesites, basalts, trachytes, tuffs and breccias.

(3) *Oligocene*—
Sedimentary, consisting of sandstones, shales, clays with seams of lignite.

(4) *Cretaceous*—
Argillaceous sandstones, grits, conglomerates and slates.

(5) *Post Palæozoic*—
Remmel granodiorite; monzonite of Copper mountain.

(6) *Palæozoic*—
Limestone, quartzite and argillite of Copper mountain. Green and spotted schists, talc and graphite schists, mica and hornblende schists, with some limestone and siliceous bands.

Palæozoic.—The oldest rocks in the district are the Roche River schists, which cover an area about the junction of the Roche river with the Pasayton. This area extends from the cañon

below the junction of the two streams four miles up the Roche river, and to a point eight miles up the Pasayton, its southern contact on the latter stream being the batholithic intrusion of Remmel granodiorite, while on the Roche river it is in contact with a band of gneiss, which may or may not be only a phase of the Remmel granodiorite. On all other sides the schists are overlaid by recent volcanic rocks lying a short distance back from the river banks. The schists are very varied in character. On the south are micaceous and hornblendic schists, frequently very siliceous and becoming gneissic, and holding some bands of crystalline limestone. The northern part of the area is occupied by soft green spotted and chloritic schists, with smaller bands of graphitic and talc schists, the latter being frequently mineralized and traversed by quartz-filled fissures. It has been found impossible to determine the age of these rocks, and though some members of the series have a lithological resemblance to the Archæan of the Shuswap series, the green and spotted schists are more probably highly metamorphosed volcanic rocks.

The limestones, quartzites and argillites cover a very limited area, but are important as being associated with some of the ore bodies in the southern part of the Copper Mountain district. They also form a highly altered and metamorphosed band crossing the Similkameen river below Allison, and lying between and under young volcanic rocks on the west and a great mass of granite on the east. They also extend some distance south of Copper mountain, until they are covered by Tertiary volcanics. They appear to resemble somewhat the Cache Creek series of the Kamloops district. They have been cut and greatly disturbed by later intrusions of igneous rock, nd so much of these beds has been destroyed that they now frequently only appear as islands or "roof pendants" in batholithic masses of rock. The limestone is very often white and crystalline, and the argillites and quartzites are very highly altered and may in some cases have taken on a crystalline structure. In addition to the metamorphism they have undergone some fracturing and brecciation. Much of these sedimentaries is probably covered by volcanic flows, and much also has been digested and assimilated by eruptive masses of plutonic rocks, and the parts that remain are only remnants of once more extensive sediments that covered a great part of southern British Columbia.

Post-Palæozoic.—These are batholithic intrusions, and under this head are classed the Remmel granodiorite of the Pasayton river, the gneiss of the Roche river, which is probably only a phase of the Remmel granodiorite, and the monzonite of Copper

mountain. The Remmel granodiorite is cut across by the Pasayton river, and extends northward from the Boundary Line for a distance of four miles to its contact with the mica schists. South of it is a large area of Lower Cretaceous rocks. The typical rock of this area is composed of hornblende, biotite, quartz and orthoclase feldspar. On the same strike as the Remmel granodiorite on the Roche river is a band of gneiss about two miles wide. This is not so coarsely crystalline and is so much more basic in composition as to be almost a diorite, but it is possible that the two may have been produced from the same magma.

The country rock of Copper mountain is a monzonite, petrographically very similar to the monzonite of the Rossland district. Its texture is granitic. The predominant feldspar is plagioclase, generally idiomorphic, and occurring in elongated crystals. Much orthoclase feldspar also occurs. The ferromagnesian minerals are biotite and augite, in varying proportions. Usually the augite is in excess of the biotite. Hornblende also occurs, but never in as great a proportion as either the augite or biotite, and probably only as an alteration of the augite. Iron or copper sulphides appear to be always constituents of the mass and occur as idiomorphic crystals disseminated through the body of the rock.

This monzonite is best developed in the south and east of Copper mountain, where it has not been affected by mineralizers or altered by later igneous intrusions. In places where this is in contact with some remnants of the older sedimentaries a gneissic structure has been induced in it. To the centre and north it has been fractured and brecciated, and is now traversed by many little veinlets of calcite, magnetite and feldspar. The rock has also become finer in grain, and large biotites are often developed in the zone of fracture. The contact between the monzonite and the sedimentaries is very irregular wherever it is exposed. It is rarely sharply defined, and in many cases no definite boundary can be assigned to the igneous rock. The monzonite occurs under so many different phases, and is cut by so many different types of dikes with which it becomes intimately mixed, that it is often difficult in the field to separate the different intrusions.

Cretaceous.—Lower Cretaceous rocks cover a wide area in the southwest corner of the district. They appear on the Pasayton river, just north of the Boundary Line, and striking about 330° across the Roche river, about six miles above the junction of that stream with the Pasayton. At both these places they are seen to overlie the eruptive rocks. The beds consist of hard sand-

stones and grits, interbedded with black and red argillaceous slates, all of which appear to have suffered much stress and pressure, for the angles of the dip are now all high, being usually about 50°. On the Roche river the bottom bed is a conglomerate, which rests directly on the gneiss to the north of it. The actual contact is masked by drift, but from the evidence of the pebbles contained in the conglomerate the latter appears to rest unconformably on the igneous rock, and the material for the conglomerate was derived from the breaking down of the igneous rock. Dr. Daly has estimated that a thickness of 10,000 feet of arkose sandstones alone was deposited in this down-warped Cretaceous sea, so that the conditions for their deposition must have covered a relatively long period of time.

The beginning of the Tertiary times witnessed some colossal disturbances in this portion of the earth's crust, which was later accompanied by much volcanic activity. The Cretaceous strata were folded and upheaved to form the rugged conditions obtaining in the Hozameen range, and it is probable that the same causes were responsible for the fracturing and fissuring of the monzonite of Copper mountain. If this is so the beginning of the formation of the Copper mountain ore bodies must have dated from this period of disturbance.

This period of disturbance and mountain building must have terminated, or was at least temporarily arrested, about the close of the Eocene period, and a short period of comparative quiescence followed, during which the lignite-bearing sediments were deposited in a local sea of transgression. Many oscillations of level of this sea are necessary at this period to account for the formation of the different seams of lignite, and the final uplift was followed by a prolonged period of tremendous volcanic activity, during which the greater part of the country south of Princeton was covered by volcanic rock.

Oligocene.—These sedimentary rocks alone in the northern part of the district cover an area of nearly fifty square miles, the basin being fourteen miles long with a variable width of from three to five and a half miles. They consist of thick beds of sandstone, with clay, shales and several seams of lignite. The base of the series appears to be a very coarse-grained sandstone containing many large rounded white feldspars in a matrix of calcareous material. This rests on the eastern side of the basin, on the Copper Mountain series of rocks, while on nearly all other boundaries the sediments dip under the more recent volcanic rocks, which lie as sheets on them. In parts also these volcanics have thrust themselves through the sediments and now appear as

islands in the older rocks. The strata do not now lie horizontally, but have been tilted at low angles, making an irregular series of folds. Some faults also occur.

Many drill holes have been bored in this Tertiary basin in search of lignite seams, and with some good results. Most of them, however, were put down at or near the edge of the river, and only one near the western edge of the basin. By the kindness of Mr. Ernest Waterman, manager of the Vermilion Forks Mining and Development Company, copies of the records of these drills have been obtained. These have disclosed the thickest lignite seams to be in the vicinity of the town of Princeton, where a bed over eighteen feet in thickness was struck at a depth of forty-nine feet below the surface. The hole in which this seam was found was sunk near the bridge over the Similkameen river to a depth of 280 feet. In this hole lignite seams, aggregating thirty-five feet seven inches, were crossed in the first ninety feet, while the rest was in shales and sandstones.

The following is a record of this drill hole:—

Material.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Gravel	14			
Shale	21	6		
Coal	4	6		
Sandstone	0	5½	40	5½
Coal	6	7½		
Clay	1	10	48	11
Coal	18	5½		
Shale	3	1		
Carbonaceous shale	4	6		
Clay	0	5		
Carbonaceous shale	0	8		
Sandstone	1	7		
Fire clay	2	1		
Coal	0	2		
Shaly coal	1	1		
Shale	1	0	81	11½
Coal	1	8		
Clay	1	4		
Coal	1	6		
Shaly coal	1	2		
Coal	1	6		
Clay, shale, etc	26	4½		
Sandstone	31			
Clay, shale, etc	79	6	227	
Sandstone	44	6		
Clay, shale, etc	8	6	280	

Aggregate of clean coal, 34 feet 5 inches.

One and a half miles further up the Similkameen river the following section was obtained of the measures by the Vermilion Forks Mining and Development Company, in bore hole No. 2:—

Material.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Clay	17	0		
Shale	18	0		
Sandstone	1	0		
Shale	36	0		
Sandstone	1	9		
Clay	2	9		
Carbonaceous shale	3	0	79	6
Coal	1	0		
Clay	7	4		
Coal	0	2		
Sandstone	27	11		
Shale	1	7		
Clay	12	6		
Shale	6	6		
Sandstone	17	7		
Shale	1	5		
Sandstone	41	7		
Carbonaceous shale	4	0	201	1
Coal	5	0		
Carbonaceous shale	3	6		
Shale	3	6	213	1
Coal	1	7		
Clay	2	11		
Shale and sandstone	23	1	240	9
Coal	3	0		
Sandstone and shale	16	0		
Coal	0	9		
Shale and sandstone	41	7	302	1

Aggregate of clean coal, 11 feet 6 inches.

The deepest hole bored in the whole coal basin was Blakemore's No. 2, which was sunk to a depth of 1,000 feet at a point on the Similkameen river, about two miles above Princeton. The following record shows the thickness and the depth at which each coal seam was cut. The only workable seam was struck at 676 feet. This was found to be ten feet seven inches thick, with a clay parting of six inches near the middle of it:—

Depth.	Thickness of coal seam.
At 95 feet	1 inch.
95 " 4 inches	1 "
395 " 8 "	2 inches.
404 " 0 "	2 "
427 " 2 "	8 "
475 " 6 "	6 "

Depth.	Thickness of coal seam.
At 479 feet 0 inches	4 inches.
508 " 9 "	3 "
579 " 4 "	2 "
579 " 8 "	2 "
676 " 8 "	10 feet 7 inches.
694 " 6 "	1 inch.
699 " 3 "	1 foot 3 inches.
793 " 2 "	1 " 0 "

Total thickness of coal in 1,000 feet, fifteen feet.

Four miles up the Similkameen river a bore hole, sunk to a depth of 257 feet, only went through two feet five inches of coal; while a drill hole near the south end of the basin at Ashnola, which penetrated to a depth of 398 feet, gave no workable seams at all, and only a few bands of what has been called in the record "coaly shale."

A bore hole was also drilled near the western edge of the basin, where the sediments dip under the volcanics, and not far from where there is an outcrop of coal four feet thick. The depth of the hole is 863 feet, and in that distance seventeen seams of coal were cut through with an aggregate thickness of fifty and a half feet, of which the thickest seam was nine feet.

From a study of these records it would appear that most, though not all, of the workable seams are within 300 feet of the surface. It must be noted, however, that no prospecting by drilling has been done north of the Similkameen river.

The coal basin undoubtedly extends some distance north of the Similkameen river and beyond the limits of the sheet mapped, for outcrops of lignite and sandstone were found at the mouth of Summers creek. Two miles up this creek the sandstones are well exposed on the banks of the stream, and are here found to be overlaid by recent volcanic rocks. Farther north they appear to dip below the surface, but it is very likely that other areas of these coal measures may be discovered outcropping in places between here and Nicola lake.

Lignite outcrops in many places, both on the Similkameen and Tulameen rivers, also on Summers creek, Bromley creek and on Nine-mile creek. At the latter place a cut in the bank made by the stream discloses a bed fifteen feet in thickness of fairly clean lignite, with five very thin partings of clay, and all resting on white clay.

A selected sample from the big eighteen-foot seam at Princeton, worked by the Vermilion Forks Mining and Development Com-

pany, was sent to Mr. Hoffmann, of the Geological Survey Department. After analyzing it he found it to be a lignite, but one of the better class. Analysis by fast coking gave the following result:—

Hygroscopic water	16.17	per cent.
Volatile combustible matter	37.58	"
Fixed carbon	41.67	"
Ash	4.58	"
	100.00	
Coke, per cent	46.25	

Character of coke, pulverulent; colour of ash, brownish yellow.

Last year Mr. Lawrence Lambe of this Department was able to correlate these lignite beds with the Coldwater group of Nicola lake, and similar beds on the Horsefly river. As a result of his investigations they have all been referred to Oligocene age, and are similar to the Amyzon beds of Colorado.

Though these beds are of the same age as the Coldwater group of the Nicola country, in which coal also occurs, there is a difference in the quality of the fuel contained in each. The Nicola coal is a true bituminous, whereas this is a lignite. The former, also, is considerably higher in fixed carbon and lower in water, while the fuel rate is 1.447, as against 1.108 of the Princeton coal.

Some of the beds of the Princeton coal basin are only in a primary stage of formation, and they still show the brown, woody fibre of the slightly altered vegetable remains. Much retinite also occurs in them. Some also have been completely destroyed by combustion, and it is to the combustion of an underlying bed of lignite that Dr. Dawson attributed the metamorphism and colour of the rocks at the Vermilion bluffs.

Post-Oligocene.—The solid rocks of this age are all of volcanic origin. They have a very wide distribution and prove that this part of the country was the scene of tremendous volcanic activity during that period. Their area must have been considerably diminished during the glacial period, so that their present distribution cannot be taken as indicative of their original extent. Detached areas of these rocks, too small to be mapped, are often found capping the older rocks, and these must at one time have been continuous with the larger areas, but have been separated from them by erosion. An instance is on record where these volcanic rocks have acted as a shield to the underlying rocks, preventing the erosive action of glacial ice from removing the

decomposed material of these underlying rocks, and only going so far as to remove the overlying volcanic sheet; so that now there is a much greater thickness of decomposed rock than is usually found in much glaciated regions, and a local condition has been produced which resembles the unglaciated regions of the Southern States.

These volcanics are the youngest rocks in the district, for they are seen on the Tulameen river and also on One-mile creek and Summers creek to rest directly on the rocks of the lignite series. On the Tulameen river the stream cuts through beds of clay, shale and sandstone overlaid by these volcanics for a distance of at least two and a half miles. The schists of the Roche river are overlaid by these volcanics to the north, east and west, and they also overlie the Copper Mountain series on the north and west. They consist of rhyolites and trachytes, andesites, basalt, tuffs and breccias. The surface lavas are often amygdaloidal, the vesicles being filled with chert, chalcedony or zeolites. Some agates and semi-opal were found in the volcanic area east of the Coldwater river.

Some of these dikes cutting the Copper Mountain rock appear to be contemporaneous with these volcanic rocks, and in some way connected with them.

ORE DEPOSITS.

In the Roche River district the mineralized area is confined to a belt of soft talc, chloritic and hornblendic schists, lying about the junction of the Roche with the Pasayton river. The ore bodies are of two classes—(1) small gold-bearing fissure veins; (2) larger bedded veins, copper-bearing. The first are usually quartz veins from three inches to four feet in width, cutting across the strike of the schists, and dipping at angles from 60° to 90°. They carry, besides gold, bornite, tetrahedrite, chalcopyrite and pyrite. Sylvanite was also reported to occur, but an assay of a selected sample of one of the veins supposed to carry this mineral gave no trace of tellurium.

The second class contains larger ore bodies, lying parallel to the strike of the schists. These may be either quartz or mineralized bands in the schists. These carry some gold and the copper and iron sulphides, and the highest values are in copper.

Only two claims have been crown granted and surveyed, and the amount of development work done on all of them is not sufficient to prove the ore bodies, or test their permanence. The

surveyed claims are the Pasayton and the Sailor Jack. On both these are small fissures. On the Pasayton is a fissure four inches wide from which samples were taken to test for tellurides, and on the Sailor Jack a fissure two feet wide cutting across a hornblende schist.

The greatest amount of work has been done on the Red Star and Anaconda claims. On these there is a belt of soft talc and chloritic schist about 400 feet wide, striking 125°, and dipping vertically, and lying between mica schists. It appears to be traversed by a fault plane, along which bunches and lenses of white feldspar and quartz have been found, and which were first worked for their gold content. On development the vein ran into the talc schist, which proved to be highly mineralized with copper carbonates, melaconite and cuprite, and which was farther on replaced by bornite and chalcopyrite. Along with these were pyrite and arsenopyrite, siderite and some blende. A shaft has been sunk in the tunnel to a depth of sixty feet, but this had to be abandoned on account of the noxious gases. Some native copper occurs as sheets in little slips and fault planes in the schist.

Several other claims have been staked in this district, and though there are some indications of high grade ore occurring, the only work done on them has been just that which is sufficient to enable the owners to hold their claims.

Copper mountain was reported on by Mr. W. F. Robertson, the provincial mineralogist, in August, 1901, and his report appears in the Annual Report of the Minister of Mines for British Columbia of that year. Since then development work has been extended farther to the eastward, but little more has been done in the neighbourhood of the river. In speaking of Copper Mountain camp and Copper Mountain ore bodies, it will be distinctly understood that Kennedy mountain will be included as well, for no distinction can be drawn between the two.

The camp includes about one hundred and thirty crown granted mineral claims, covering an area five miles long from east to west, and about four miles from north to south. Combination camp lies to the south of Copper mountain, but the ore bodies are much the same in character.

The country rock is a batholithic mass of igneous rock of very variable composition. It was found exceedingly difficult to classify it in the field on account of this variableness. From one part of the field to the other it appeared to range from an augite syenite to a gabbro, and as a mean between these two it was called in the Summary Report a diorite. On microscopic study, however, it was found to be a monzonite, very similar to the

monzonite of the Rossland district. This has intruded into and almost entirely digested the older overlying sediments—limestones, argillites and quartzites—so that these only now appear as inclusions or remnants in the igneous rock. To the north and west it is overlaid by recent volcanic rocks. Along the southern and eastern border of the mineralized area the typical rock is best developed. Here, too, a gneissic structure is sometimes observed, or the dark minerals occur in segregated areas. To the north the rock becomes more feldspathic, and is cut by narrow veins of pink feldspar, quartz and magnetite.

Both the sediments and the igneous rock are intimately mixed with and cut by a multitude of later dikes of different ages, whose sequence cannot yet be perfectly worked out. These dikes have a general north and south trend and are quartz porphyry, rhyolite, granite porphyry, diabase and augite porphyrite, of which the first mentioned are apparently the most frequent. The whole series, except the later dikes, is traversed by a set of fracture and fault planes running in an almost east and west direction.

Two classes of ore bodies have been made out (1) those occurring at or near the contact of the sediments with an igneous rock, and (2) those occurring in the zones of fracture. Both are of a very indefinite character, without well-defined boundaries. Examples of the first class are found at the southern end of Copper mountain, and on the west side of the Similkameen river. In this class ore is frequently found at the contact of the monzonite with a limestone, which may be very much altered. The ore here generally occurs as infiltrations in the small fracture planes with which the rock is traversed. The fissures cut both the igneous as well as the sedimentary rocks, and the metallic sulphides are found in both, but only in the neighbourhood of the contact. The fissures have been filled with secondary calcite, which acts as the gangue of the sulphides. Rhyolite and quartz porphyry dikes cut both kinds of rocks, and have apparently been injected after the fracturing and fissuring had ceased, for they are not themselves affected by any such dynamic action. The intruded rock alone has been fissured to allow of the flow of mineralized solutions. These later dikes are not in themselves mineralized, and do not appear to have had anything to do with the formation of the ore bodies. In the Jennie Silkman claim a highly mineralized diabase dike, which cuts an altered sedimentary rock along with a quartz porphyry, seems to be responsible for the formation of the ore. The minerals occurring in this class are chalcopyrite, pyrite, pyrrhotite, bornite and calcite, with a little

magnetite. Bornite is confined to the southern portion of the camp. The Sunset, Helen H. Gardner, Jennie Silkman and Copper Farm claims are examples of this class.

The second class of ore bodies occurs in the centre of Copper mountain and eastward across Wolf creek. In this case the ore occupies a zone of fracturing, which strikes about north 75° east. It often happens that the country rock has been brecciated and the fragments cemented together by calcite, or it is traversed by a network of small calcite veins with a north 75° east trend. These fissures are most abundant about the middle of the camp, and die out to the north and south. They sometimes attain a width of two feet, but are more often only an inch or two. They cut all the rocks except some of the later dikes. These dikes strike at right angles to the course of the fissures, cutting off the ore bodies, and they do not seem to have been affected by any strains or stresses, except those which are consequent on the cooling of the igneous body. Pyrite, chalcopyrite, mispickel and magnetite occur in the calcite veins. Magnetite sometimes replaces the calcite altogether in the veins, and forms the gangue for the other minerals. In the northern part of the district the little fissures are filled with feldspar, quartz or magnetite to the entire exclusion of calcite. The Triangle Fraction, Red Eagle, Ada B., Frisco, Annie L. and other claims running east and west across the middle of the camp are examples of this class.

Besides being concentrated in the zones of fracture the copper and iron sulphides appear often to be original constituents of the monzonite, for they appear as idiomorphic crystals, disseminated through it without any connexion with each other, and until a great deal more development work is done on the claims it will be difficult to give a correct history of the formation of the ore bodies. At present not many claims have been explored to a depth lower than the limit of surface oxidation. Some deep drilling had been done on the Princess May and other claims during 1905, but the results have never been made known.

It will be noted that one of the features of these ore deposits is the association of the oxides of iron with the sulphides, magnetite occurring with pyrite and chalcopyrite, a feature which has been considered by the best authorities to be characteristic of contact deposits, and particularly the contact of limestone or a calcareous rock with an igneous one. Though it is not always possible on Copper mountain to discover an igneous rock and limestone contact, wherever this association of oxides and sulphides occurs, it must not always be inferred that there never was one there. Many small areas of limestone and argillite have

been found as inclusions in the monzonite, a fact which goes to prove that before the intrusion of the monzonite the country rock of Copper mountain was a sedimentary one composed of these rocks, and that the monzonite had eaten into and assimilated all but the remnants that now exist. It is probable, however, that the molten magma never actually reached the surface, but cooled at depth under great pressure into a rock of granitic texture while the sediments still overlay it. Extensive erosion may have followed, going so far as to remove almost entirely the overlying sediments, and bringing to the surface the intrusive granular monzonite and its once deep-seated contacts with the sediments; or even going beyond this so that the sediments were removed entirely and the monzonite exposed, but still showing the effect of contact metamorphism. It would be premature at the present stage of development of the camp to say how much of the mineralization is attributable to the effects of contact metamorphism, but it appears altogether likely that the first class of ore bodies mentioned may be referred to this cause, while possibly there may have been a later fracturing and fissuring with mineralization to account for the second class.

Owing to the nature of the occurrence of the ore on Copper mountain it is a difficult matter to make estimates of the average values that the rock would give on assay. The ore bodies have no definite boundaries, in fact the whole mountain is more or less mineralized with concentration taken place along certain lines, and what is classed as ore to-day may be too low a grade to give a profit tomorrow, depending altogether on the price of copper and the cost of mining. The boundaries then will be merely commercial ones. Mr. W. F. Robertson made assays of samples from many of the different claims in 1901, and the results he obtained were from one and a half to three per cent in copper of average samples, with selected samples going up to eight per cent. Most of them carried a small amount in gold. It will be seen by this that these ore bodies are very low grade, but this is compensated for by their great size and the ease with which they can be worked.

In the country lying between One-mile and Five-mile creeks, and on the slope of Five-mile creek, several claims have been located, but only the western portion of this area came within the district examined. The United Empire group, consisting of nine claims, is on Allison mountain, and occurs in the same series of metamorphosed sediments as occupies Kennedy mountain. The whole hill is heavily covered with wash, and the rock, wherever exposed, is decomposed to a much greater extent than

in any other part of the country, due perhaps to a covering of volcanic flows during the glacial period, which prevented this decomposed rock from being removed by the scouring action of the glacier. At the base of the hill is a thick deposit of clay and detritus washed down from the hill, and heavily charged with copper carbonate. This has probably been derived from the leaching out of a copper-bearing quartz vein higher up the hill carrying the sulphides of copper. Evidence in support of this is drawn from a shaft forty feet deep sunk about half way up the hill, at the bottom of which blocks of quartz, carrying chalcopyrite, occur in the decomposed rock. It is probable that there is a vein of quartz carrying copper at this place, but not enough work has been done to demonstrate the size of the vein or its strike. Surface indications, however, point to its having an east and west strike across the strike of the country rock, and in conformity with the strike of the fracture planes on Copper mountain.

BEAR CREEK.

At the end of the season a hurried reconnaissance was made of a mineralized belt of rocks running from the Tulameen river, at Champion creek, northward past the head of Bear creek, to the Coldwater river. Some very promising mining properties are being exploited in this region, and this belt of rocks well warrants a more extended geological study.

Briefly stated the geological conditions are as follows:—Stretching across in a northerly direction from the mouth of Champion creek to the head of Coldwater river is a belt of light-coloured granite. In contact with this on the east side is a series of metamorphosed sediments—limestones, quartzite and schists—extending from the Coldwater river to the Fish lakes. From the Fish lakes to the forks of Eagle creek the granite is in contact with a dike-like mass of peridotite a mile or two wide, which then strikes easterly at a sharp angle with the strike of the granite. In this angle, between the granite and the peridotite, is another small area of quartzite, limestone and mica schists, which extends south to the Tulameen river and terminates at Champion creek. Bordering the peridotite and schists on the east is a large body of pyroxenite, which extends from the falls on Bear creek, where the wagon road crosses it, southward across the Tulameen river, where it comes in contact with the granite. The pyroxenite is succeeded on the east by enormous masses of volcanic rocks, which have undergone considerable metamorphism, and are earlier in age than those volcanic rocks previously

referred to in this report as occurring on the southern portion of the Similkameen river. Dikes of diabase, quartz-porphyry and granite-porphyry cut all the other rocks and are consequently later in origin.

Contacts between the granite and schists, between the granite and peridotite, and between the schists and peridotite and pyroxenite, were discovered and studied in the field, and from these the geological relations were worked out. The schists, which are probably metamorphosed sediments, with the limestones and quartzites, are the oldest rocks in the district, for they are cut by all the others and are found as inclusions in the granite and in the peridotite. Next in age comes the peridotite, and with this must be included the pyroxenite, though the latter is slightly the younger, for on Eagle creek dikes of pyroxenite were found cutting the peridotite. Prof. J. F. Kemp, who examined the district in 1900, reports the same conditions on the south side of the Tulameen river. The next rock in the sequence is the large batholithic mass of granite lying to the west. Contacts between this and the older rocks are well shown on the Tulameen river and on Eagle creek. Following the granite intrusions are the sheared and metamorphosed volcanic rocks, and later again are the dikes which have penetrated all the preceding rocks.

Mineral claims have been located all along this granite contact from Champion creek across to the Coldwater river, and for many years the placers of the Tulameen river and its tributaries below Champion creek have been profitably worked for gold and platinum. These placers are being gradually exhausted, and the Tulameen river, from being the principal producer of platinum on the North American continent, has dwindled down to an annual output of thirty or forty ounces of that metal. Mining activity, however, is now being revived, and the production from lode mining will probably soon be far greater than it ever was in the best days of the placer miner.

Most of the mineral claims have been located in the area of schists, limestones and quartzites, and some in the peridotite and pyroxenite belt. The metals for which they have been staked are gold, silver and copper; and the minerals occurring are pyrrhotite, pyrite, galena, chalcopyrite and calcite, with some zinc blende and molybdenite.

Molybdenite is found in several places along the granite contact. At Independent camp, at the head of the Coldwater river, it occurs in fine scales in the granite porphyry, and at Champion creek it is found in little quartz stringers cutting the schists at and near the contact with the granite.

Among the most promising claims in the whole district are the St. Lawrence group, owned by the Similkameen Mining and Smelting Company of Vancouver. These were first located in the fall of 1900 by a party of Swedes, and are situated on the western side of Bear creek, and on the contact of the granite with the schists and limestones. The schists are mica schists, and they are interbedded with narrow bands of crystalline limestone. They dip at about 65° towards the granite, and are cut by some large and highly mineralized dikes of granite-porphyry, which have a north and south trend approximately parallel to the trend of the granite. The ore is always found associated with the limestone, and frequently replaces the lime bands entirely. The granite porphyry dikes appear to be the source of the ore. The limestone being the most soluble rocks have acted as channels for mineralized solutions from the dikes, and they have at times become entirely replaced by sulphides. These solutions ascending from below and following the lime bands have deposited their sulphides against the mica schist, which always acts as a hanging wall to the vein. Two veins have been opened up on this group, each of them from seven to eight feet wide, and the ore in them appears to be almost pure pyrrhotite. The values are high in copper, gold and silver, and altogether the property has the ear marks of a permanent producing mine.

Another important group of claims is the Independent group, owned by Messrs. Johnson, Holmes & Henning, and situated on the summit of the divide between Bear creek and the Coldwater river. This group is also on the contact of the granite body with mica schists. Here the ore body is a highly mineralized zone of rock extending from the edge of the schists about 1,000 feet westward into the granite. Two thousand feet away from the schists the granite becomes gneissic, though still holding inclusions of the mica schists. No sharp line of contact could be discovered between the ore body and the unaltered granite, only that the mineralization by sulphides appears to gradually decrease until at 1,200 feet away from the schist it disappears. The ore body is highly altered and kaolinized, where mineralization is greatest, and it appears to be of the nature of a dike of granite-porphyry intruded between the schists and the granite, though it is possible it may only be a mineralization and alteration of the same granite at and near the contact with the schists. Inclusions of mica schists occur in the unaltered granite, as well as in the ore body. The greatest alteration is about the centre of the mineralized zone, where a small vein of pure iron and copper sulphides cuts the porphyry at an angle of 45 degrees. The

feldspar here is kaolinized, though the quartz is unaltered, and some secondary calcite has been developed. Mineralization throughout the body of the porphyry is usually by individual crystals of iron and copper pyrites, more rarely by veins and bunches of these minerals. Only in the highly altered zone does oxidation extend to a depth of twenty feet from the surface. Some molybdenite occurs in thin seams and flakes near the contact with the mica schist. The values are entirely in copper, and are low, but the ore body is an enormous one. The group consists of ten claims, which have all been staked on the same contact, running down into the Coldwater river.

Numerous other claims were visited in this section of country, among them being the Keruna group on Bear creek, and the Boulder Creek camp, east of Bear creek. The former lies in the same series of altered sedimentary rocks as were described on the St. Lawrence group. These are cut by dikes of a porphyritic character, which strike about 330°. The ore occurs as little veins and bunches in the sediments at and near the contact of the dikes. The minerals found are pyrite, chalcopyrite and pyrrhotite, and the values are in gold and silver.

At Boulder creek the claims are located in a soft, green serpentine, which often has a schistose structure developed in it, and which appears to be an altered volcanic rock. These ore bodies are in blanket veins, interbedded with the country rock, and the minerals occurring are pyrite, chalcopyrite and some galena. The values are in gold or copper, or both, the one increasing as the other decreases.

Owing to the enormous rise in the price of platinum in the last year, and to the fact that the basin of the Tulameen river once produced a larger amount of platinum than any other part of North America, it is altogether probable that attempts will again be made by interested parties in the near future to locate the source of the metal in this district, or to work some of the higher bench deposits of gravel which are known to carry platinum, but which necessitated too large an outlay of capital to have been worked before. Prof. J. F. Kemp spent about three months in the summer of 1900 in investigating the geology of the platinum, and though he was not successful to the extent of finding any large bodies of rock which could be profitably mined, he was able to throw a great deal of light on the origin and occurrence of the metal. His results are embodied in bulletin 193, of the United States Geological Survey.

The Tulameen section of the country presents a great many more difficulties to the prospector than the Similkameen country.

The former is very heavily timbered and trails are few and rough. Rock exposures, however, are most common, except where the country is underlaid by the schists and limestones, as in the upper parts of Bear creek. Here the growth of the timber is heavier than usual, and the country is so covered with drift that rock exposures very rarely occur, and it has only been by much labour that ore bodies have been located. It is here, though, that conditions for the formation of ore bodies are so favourable that other important discoveries are to be looked for in the future.

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GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DEPUTY HEAD AND DIRECTOR

THE TELKWA RIVER AND VICINITY

B. C.

BY

W. W. LEACH

OTTAWA
GOVERNMENT PRINTING BUREAU
1907

No. 988

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GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DEPUTY HEAD AND DIRECTOR

no. 7

THE TELKWA RIVER AND VICINITY

B. C.

BY

W. W. LEACH

OTTAWA
GOVERNMENT PRINTING BUREAU
1907

No. 988

CONTENTS.

ERRATA.

(1). Page 9, fifteenth line from top, after "canoes," insert a comma, and after "horses" add " : made to swim."

(2). Page 12, fourteenth line from bottom, for "Gleichemia" read "Gleichenia."

(3). Page 14, eleventh line from bottom, for "southwest" read "southeast."

(4). Page 19, tenth line from bottom, after "extent of" add "the."

(5). Page 21, nineteenth line from bottom, for "intermediate" read "immediate."

A. P. Low, Esq.,
Deputy Head and Director,
Geological Survey of Canada.

SIR,—Herewith I have the honour to submit the enclosed report on my explorations on the Telkwa river, Skeena Mining division, British Columbia. The report is accompanied by a geological and topographical map of the district.

I have the honour to be, sir,
Your obedient servant,

W. W. LEACH.

OTTAWA, April 25, 1907.

THE TELKWA RIVER AND VICINITY

BY

W. W. LEACH.

It is only within the past few years that much attention has been paid to prospecting in this region, at least in regard to quartz and coal, as much of this country has previously been run over by prospectors in search of placer gold. The commencement of construction of the Grand Trunk Pacific railway has, however, awakened much interest in this district with the result that a great part of the country has been roughly prospected, many mineral claims have been staked and much of the available arable land and timber has been taken up.

As it seems now fairly definitely settled that the railway will follow down the Bulkley valley, from its head to its junction with the Skeena, much interest has been aroused in the natural resources of the district through which it will pass, and, at many widely separated localities in and adjacent to the Bulkley valley, evidences of the presence of minerals of economic value have been found, notably on the Telkwa river, the headwaters of the Zymoetz or Copper river, and in the Babine range between the Bulkley valley and Babine lake to the east. Of these localities, the Telkwa river is probably the best known, and, during the past season, the attention of the writer was confined to its watershed and immediate vicinity, as shown on the map accompanying this report.

TOPOGRAPHY.

The Telkwa river is one of the most important tributaries of the Bulkley and rises in the Coast range; thence following an easterly course for about forty miles it joins the Bulkley about fifty-five miles above Hazelton, at the junction of the latter stream and the Skeena river.

At the junction of the Bulkley and the Telkwa rivers the former occupies a wide valley, the river itself being confined to a narrow

secondary valley cut through gravel terraces to a depth of from 100 to 150 feet.

The valley of the Telkwa itself is also terraced for a distance of about twenty miles, when the floor of the valley rises above the level of the terraces.

The Telkwa is a typical mountain stream, swift and cold, and subject to frequent and sudden fluctuations due to the presence of many large snowfields and glaciers at its head. At low water it is readily forded, but when in flood is quite impassable.

Apart from the comparatively small area of terraced country near its mouth the whole watershed of the Telkwa may be said to be mountainous. The Coast range in which it takes its rise is an exceedingly rugged and alpine chain of mountains, presenting an unusually unbroken front, stretching in a continuous array of sharp and jagged peaks as far as the eye can see in a northwesterly and southeasterly direction, while numerous glaciers and snowfields are constantly in view along its eastern slopes. The highest peak shown on the map reaches an elevation of 9,300 feet, while many are over 8,000 feet high.

Flanking the eastern slopes of the range a series of lower ridges occur, which extend to the Bulkley valley; these ridges, while by no means as rugged as the main range, still reach in places an elevation of over 7,000 feet, while the area above the 6,000 foot contour is quite extensive. They give the general impression of a dissected plateau, usually with gentle slopes towards the south and west, and showing precipitous faces towards the north and east. A few small glaciers are to be seen on the northern slopes of the highest ridges.

The topography generally, away from the main range, is quite irregular, the larger streams, as a rule, heading in comparatively low, marshy passes and following erratic courses to the main valleys, leaving, in many cases, isolated areas of more or less flat-topped mountains. This feature is well shown on the map; the valley occupied by the south fork of the Telkwa and a branch of the Morice river separating the block of mountains at the head of Goat, Glacier and Sunset creeks from that at the head of Scallon and Howson creeks.

Pine creek and the north fork of the Telkwa both take their rise in comparatively low passes with tributaries of the Zymoetz river, while the main branch of the Telkwa and a small stream entering Burnie lake head together. Burnie lake is reported to empty into a stream which eventually reaches the Kitnayakwa.

In nearly all cases the glaciers of these mountains appear to be regularly retreating, and in several instances, notably at the

head of Scallon creek, small glaciers have entirely disappeared within recent years.

TRANSPORTATION.

At present the only means of communication with the outside world is by pack train, either to Quesnel, on the Cariboo road, 300 miles to the south, or to Hazelton, fifty-five miles to the north, and thence down the Skeena by river steamer to Port Essington on salt water. Navigation on the Skeena, however, is a very uncertain quantity, as it can be ascended at moderate stages of water only, so that this route can not always be depended on.

At Aldermere, a new town situated on the Bulkley river opposite the mouth of the Telkwa, all ordinary supplies can be obtained and hotel accommodation secured.

To reach the Telkwa district from Aldermere the Bulkley has to be crossed by canoes and horses; the lack of a bridge or adequate ferry is of great inconvenience to travellers, as at high water the crossing is by no means easy.

Up the Telkwa there are a number of trails giving access to the various camps, on most of which the grades are sufficiently light to permit of the construction of wagon roads without much change of route, while Howson camp, near Moose-skin lake, which may be considered as near the centre of the chief mineral-bearing areas, could be reached by a railway from Aldermere without excessively heavy grades, should the ore deposits in that neighbourhood prove of sufficient value to warrant its construction.

As the timber line is reached at an elevation of about 5,000 feet above sea level there is a large area above it where travelling is comparatively easy during the summer months; the geological features also can be more readily examined there than in the valleys, so that the attention of prospectors has been mostly concentrated on these higher levels, and the majority of claims are staked above timber line.

TIMBER.

A great part of this district has been burned over and the original forest replaced by poplar and jackpine, but, in some of the larger valleys, such as that of the Telkwa itself, above Pine creek, and the North and South Fork valleys, much fair timber

remains, consisting chiefly of spruce and balsam, with a little hemlock and jackpine. There should be an ample quantity remaining to supply any local demand for building and mining purposes for a long time to come.

MAP.

The information for the compilation of the accompanying map was obtained chiefly by triangulation with panoramic sketches, supplemented by paced surveys of the main trails; the triangulation being based on township surveys by the British Columbia Government.

The elevation of the mouth of the Telkwa, upon which all other elevations given depend, was assumed to be 1,750 feet above sea level. This figure was arrived at from the results of a number of aneroid barometer observations between this point and Hazelton, and must be considered as only approximate. Other elevations are calculated from vertical angles checked by the aneroid.

GEOLOGY.

The rocks of the Telkwa valley may be roughly subdivided into four main divisions, consisting of, in ascending order: 1st. The Crystalline rocks of the Coast range. 2nd. The Porphyrite group. 3rd. The Coal-bearing beds. 4th. A series of eruptives, more recent than any of the above mentioned.

COAST CRYSTALLINE ROCKS.

Of the first, little can be said; they constitute the backbone of the Coast range and, where seen, consist of gneisses, schists, granites, &c., but were in no case closely examined. Dr. Dawson has provisionally classed them as of Palæozoic age, probably Carboniferous (Report of Progress, 1879-80, p. 100 B), and has given them the general name of the Cascade Crystalline series.

PORPHYRITE GROUP.

Rocks of the Porphyrite group occupy by far the most extensive area in this map-sheet. They consist of a great series of volcanics, composed of tuffs, andesites, agglomerates, &c., more

often occurring in sheets as volcanic flows but frequently showing evidences of deposition under water, more particularly towards the top of the series, and are all more or less regularly bedded.

Dr. Dawson has given the name of the Porphyrite group to this series in its southern extension in the neighbourhood of Francois lake (Report of Progress, 1876-77), and has provisionally correllated it with the volcanics met with on the lower Skeena (Report of Progress, 1879-80, p. 129 B). From fossil evidence he has classed it as Lower Cretaceous, and, in the Francois Lake district, has estimated the thickness of these rocks to be over 10,000 feet. As no fossils were found in these beds during the past season no evidence of their age, beyond their lithological resemblance to those described by Dr. Dawson, is forthcoming. No attempt was made to ascertain their thickness in the Telkwa district, but it is probably not less than 5,000 feet.

The rocks of this group vary greatly in appearance in different parts of the field, in colour ranging from light greenish greys to dark purplish reds. Generally speaking it may be said that red colours predominate towards the top of the series, the beds consisting of reddish andesites, breccias and tuffs, in many cases amygdaloidal, with inclusions of calcite and zeolites. Green is the characteristic colour towards the base, the beds being composed largely of fine-grained greenish feldspathic rocks, often amygdaloidal and containing much calcite and epidote. A few specimens collected from the amygdaloidal rocks of Pine creek, from the upper beds of the series, were examined by Dr. Hoffmann, and the following secondary minerals were determined: calcite, epidote, prehnite, heulandite, mesolite and laumonite.

At the mouth of the Telkwa, on both sides of the Bulkley, there occur a number of exposures of light-coloured, altered, tufaceous rocks, much resembling sandstone in appearance; although no similar rocks were noted elsewhere in the district and it was impossible to trace their relationship to the other volcanics clearly, it seems probable that they occupy a position near the top of the Porphyrite group.

The rocks of the Porphyrite group are of great economic importance, inasmuch as practically all the mineral claims that have been staked in the district are located in them.

COAL-BEARING BEDS.

Immediately overlying these rocks, and possibly unconformable to them, although both have been subsequently folded and

faulted to such an extent that their immediate relationship to one another is somewhat doubtful, occurs a series of beds composed chiefly of clay shales and containing a number of important coal seams. The lower member of these beds consists of a coarse, loosely-cemented conglomerate, mainly composed of pebbles from the underlying volcanics, in places shading into a coarse grit and not more than sixty feet in thickness in any place seen, but, on account of its characteristic appearance and permanency throughout the field, affording a very valuable reference horizon when prospecting for coal. This is followed by some thin-bedded clay shales with a few soft, thin, crumbly beds of light-coloured sandstone, succeeded by more clay shales and coal, the shales being often carbonaceous and containing many beds carrying numerous yellow-weathering clay-ironstone nodules. These are the youngest sedimentary rocks represented in the district, and, although not of great thickness (in no case seen showing more than 300 feet in all), they are of considerable importance on account of the coal contained therein.

A few fossil plants were collected from the coal-bearing beds of Goat creek, which were submitted to Professor Penhallow for determination. The following notes by him concerning them may be of interest:—

"No. 1.—Fine specimen of a very promising stem, which will have to be sectioned and worked out. Until microscopical sections have been prepared and studied, no result can be given.

"No. 2.—Two other fragments of stems, both highly altered and pyritized and not determinable.

"No. 3.—A very fine specimen of a fern. This is *Gleichemia gilbert-thompsoni*, Fontaine.

"Along the International Boundary Line, on the Skagit river, Dr. R. A. Daly obtained the same species. With respect to the age indicated by this plant Ward has already indicated its probable relation to the Lower Cretaceous, and in my report to Dr. Daly, on his collection, a review of the evidence seemed to confirm this view with respect to the specimens from the Skagit river. We may, for the present at least, conclude that a similar horizon is indicated for the Skeena River specimen."

These beds are overlain by a considerable thickness of glacial drift.

NEWER ERUPTIVES.

All the above rocks are cut by a series of eruptives consisting of coarsely-crystalline porphyritic rocks which have thrown out

dikes in all directions and have crumpled and dislocated the volcanic flows and coal-bearing strata in their vicinity to a very great extent. These intrusive rocks themselves are somewhat variable in appearance and composition, two distinct facies having been noted in the Telkwa district; the small area at the head of Glacier creek consisting of a coarse, light-coloured, biotite granite, shading off into a granite porphyry near its edges, while the larger area on Scallon creek is composed of a pinkish syenite porphyry. The dikes from them show a large number of types.

The boundaries of these areas, as shown on the map, must be regarded as only approximate, as the eruptives have shattered and metamorphosed the volcanics near their contacts, and have caught up and included in them many small patches of the latter, so that it is impossible to define the line of contact with any degree of exactness.

In the bed of Pine creek, near its mouth, numerous boulders of similar rocks to these were noted which must be derived from one or more corresponding areas on the watershed of that stream.

These rocks appear to have a marked influence on ore deposition in this region, as they apparently afforded a channel for the ascent of mineral-bearing solutions.

It may be said as a general rule that, although the greater part of this district is underlain by rocks of the Porphyrite group, no important discoveries of minerals have been made except in the immediate vicinity of these intrusive areas and the dikes from them; it would, therefore, appear conclusive that they were instrumental in the deposition of such ore as has so far been found.

Their influence on the coal has also been important, as it has been found that as the main eruptive areas are approached, with the resulting increased disturbance of the strata, the coal becomes much more anthracitic in character. The coal seams themselves have been cut by numerous dikes in many cases accompanied by faulting, a fact that will materially affect future mining operations.

There is a possibility that within this map sheet there may be included in the area coloured as being underlain by rocks of the Porphyrite group, small isolated patches of Tertiary andesitic or tufaceous rocks, very much alike in appearance to similar rocks referable to the Porphyrite group. Such conditions exist to the south in the vicinity of Francois lake, and Dr. Dawson has pointed out the difficulty of separating the Tertiary and Mesozoic volcanic products there. (Report of Progress, 1876-7, p. 92.) Certain fossils found in a tufaceous rock near the head of Goat creek would

seem to point to the existence of such an area in that neighbourhood. These fossils (shells) were examined by Dr. Ami, who was unable, owing to their bad preservation, to give any definite opinion regarding the age of the strata from which they were obtained.

COAL.

The problem of delimiting the coal areas in this district is one of extreme difficulty. The exceedingly soft nature of the coal-bearing rocks, and their consequent failure to resist erosion, has resulted in their removal everywhere from the higher ridges, only a few detached remnants remaining in the valleys. The total thickness of the coal formation being small, probably not in excess of 300 feet, and having been folded and faulted to a considerable extent, it is seen that even in the lower valleys the volcanic rocks occupy a large extent of the area, the coal-bearing beds having been removed by denudation except in the case of a few small basins where the seams at no time attain any great depth.

The only natural exposures are to be found in the creek bottoms, in the few places where the streams have cut through the heavy covering of drift of the wide, terraced valleys to the bedrock. Away from the creeks no rock exposures need be looked for until the higher ridges are reached, and these are in all cases composed of the volcanic rocks, the actual contact being almost invariably masked by drift covering. It will, therefore, require very close prospecting before the extent of the coal areas is proved.

The areas, as coloured on the map, must be considered as showing in a general way only the extent of the basins. The exposures are all in the streams so that the lateral boundaries are not definitely known. It will be seen that the coal is found in aseries of shallow troughs with a general northwest and southwest trend, there also existing a number of minor undulations within these main synclines, and numerous small faults. The extent of the largest basin northward of the Telkwa river is uncertain, as no exposures are to be seen for four or five miles north of the river. The position of the small, isolated area on Mud creek, as shown on the map, is very doubtful; no exposures could be found on that part of the creek, but a certain amount of drift from the coal measures was seen in the stream bed about there. It is possible that this area is an extension of and continuous with the one on Cabin creek.

It is quite probable that other small coal basins exist which are not shown, perhaps at times being completely masked by drift-covering; for example, in the stretch of country from a short distance below the mouth of Goat creek to the Bulkley river no rock exposures are to be found, but it is within the range of probability that part of it is underlain by coal.

There are, at present, four companies holding coal locations in this district, all of which have done some prospecting of a desultory nature.

CASSIAR COAL COMPANY.

The Cassiar Coal Company, whose property lies in part on Goat creek, a large tributary of the Telkwa river from the southwest, have stripped several seams about six miles up that stream. The following section, in descending order, was measured by the writer in 1903 when the work had just been done. Since then the cuts have fallen in, to some extent.

	Ft.	Ins.
Clay shale		
Top seam—		
Coal with a few small clay partings	12	0
Clean coal	7	7
Clay	2	0
Grey sandy shale and covered, about	30	0
Middle seam—		
Coal	1	5
Clay shale	2	7
Coal with a few irregular clay partings	14	5
Shale with ironstone nodules	3	3
Coal	2	0
Grey clay shale with nodular ironstone bands, about	50	0
Bottom seam—		
Carbonaceous shale and coal	2	0
Coal	1	5
Shale	0	5
Coal with small irregular clay partings	9	0
Clay shale		

Analyses of the above coals gave the following results:—

	Moist.	Vol. Comb. Mat.	Fixed Carbon.	Ash.
1. Lower 7 feet of top seam	1.92	30.45	61.30	6.33
2. Lower 7 feet, middle bench, middle seam	4.70	30.40	60.80	4,10
3. Middle bench (14 ft. 5 ins.) middle seam	6.60	29.00	56.90	7.50

No. 3 analysis is by the British Columbia Provincial assayer. (Report of Minister of Mines, B.C., 1905.) No. 1 gave a dense

and non-expansive coke, while Nos. 2 and 3 were non-coking. No. 3, the only one of these tested for sulphur, showed 0.52 per cent.

This coal should make an excellent fuel as it is fairly hard and well able to stand considerable handling without much loss in slack; it is, however, apparently not suited for the manufacture of coke. The strata here dip irregularly at low angles and show several small faults.

A short distance up Goat creek from these openings, in a high cut bank, what are probably the same beds are seen, but, in this case, it appears that the two upper seams have been burnt, leaving in their place thin beds of ash and slaggy material and colouring the neighbouring shales a brick red, thus forming a very noticeable feature in the landscape. A fourth seam, overlying the others, outcrops at the top of the cut bank; it shows about two feet of coal, but no regular roof was seen, the present overlying material being the gravel wash of the terrace. It does not seem probable that the burning extends over any large area here as there is no further sign of it higher up the creek, although a couple of miles down Goat creek a similar occurrence was noted.

These exposures give what is probably the best section of the coal measures in the district, about 200 feet of strata being uncovered between the creek bed and the top of the terrace, but it is by no means complete.

Several other coal exposures were seen on the property of this company farther down Goat creek, but no other work of any extent has been done. About a mile down Goat creek from the above mentioned cuts a seam of impure coal is to be seen cut by a small dike, and both dike and coal are slightly faulted.

This company has sunk two diamond-drill bore holes in search of coal, one at the mouth of the Telkwa and the other near the mouth of a small creek entering the Telkwa about two miles above Goat creek. The first of these, said to be about 300 feet deep, was sunk in the fine-grained, sandstone-like volcanic rock described on a previous page and supposed to be of a lower horizon than the coal beds. The second was started in the conglomerate, representing the lowest member of the coal-bearing beds, and driven through to the underlying volcanics.

To the north and west of this property a number of locations are held by the Kitimat Development Syndicate. No work has been done beyond mere surface stripping at various places. On Mud creek, a branch of Goat creek from the southwest, near its mouth, and on the Telkwa river a few miles above the mouth of Goat creek, the coal has been exposed by the action of the stream;

several good seams are uncovered of a nature very similar to those of the Cassiar Company on the north side of the Telkwa, one seam showing twelve feet of coal with the floor below water level, but in all cases the strata are subject to faulting as elsewhere in the field.

TRANSCONTINENTAL EXPLORATION SYNDICATE.

The coal lands of the Transcontinental Syndicate are situated on Goat creek, above those of the Cassiar Coal Company, and separated from the latter by rocks of the Porphyrite group, here exposed along the axis of an anticline. During the past season two prospecting tunnels have been driven, and a shaft sunk, with the intention of proving the number, size and condition of the seams at this point. At the close of last season No. 1 tunnel had been driven a distance of one hundred and forty-six feet across the strike of the measures, the strata here dipping at about thirty degrees. Five seams had been cut in ascending order, three feet six inches, two feet eight inches, four feet nine inches, three feet and one foot, respectively, in thickness.

No. 2 tunnel, fifty-five feet in length, also cross-cutting, had passed through two seams, the lower six feet six inches, and the upper two feet eight inches, thick. The roof of the larger seam is missing, a fault having cut through the seam here, but it is probable that this is the same bed that is shown in a natural exposure a short distance down the creek, where about ten feet of coal is in sight.

No. 2 tunnel cuts the strata at a slightly higher horizon than No. 1, and it is probable that the two upper seams in No. 1 tunnel are the same as the large lower seam in No. 2.

Near the entry to No. 1 tunnel a shaft had been sunk to a depth of thirty-seven feet to prospect the strata at a lower horizon than could be reached by the tunnels, but no coal was found.

An attempt to combine the sections afforded by these three openings shows the following results, in descending order:—

	Ft.	Ins.	
Shale	..	..	
Coal	2	8	
Shale	12	0	This thickness uncertain as a fault intervenes.
Coal	6	6	This seam split in No. 1 tunnel.
Shale	13	0	
Coal	4	9	
Shale	19	6	
Coal	2	8	
Shale	3	0	
Coal	3	6	
Shale	52	0	
Total	119	7	
Coal	20	1	

The coal measures at this point, being nearer to the later eruptive areas, are more highly flexed than those farther down Goat creek and evidences of faulting are abundant. Although, in all probability, the same seams are represented here as those mentioned before on the Cassiar Coal Company's land, the character of the coal is entirely different, as the following analyses show:—

	Moist.	Vol. Com. Mat.	Fixed Carbon.	Ash.
No. 1. Seam 2 ft. 4 ins., 200 ft. down creek from No. 1 Tunnel (non-coking)	0.80	8.20	81.60	9.40
No 2. Six foot seam of No. 2 Tunnel (non-coking)	0.90	9.90	75.80	13.40

No. 1. Analysis by British Columbia Provincial Assayer. (Report of Minister of Mines, B.C., 1905.)

This coal is firm and bright, and may be classed as a semi-anthracite, and should make a most excellent fuel of its kind.

As has already been mentioned, on the nearer approach to the newer eruptive areas the older rocks, including the coal beds, have been highly disturbed and the resultant heat and pressure have had a marked effect on the coal, altering it from a bituminous to a semi-anthracite; it must be expected, however, that more difficulties will be met with in mining, due to the probable greater frequency of faulting and increased intensity of the folding.

TELKWA M., M. AND D. CO.

Similar conditions, if anything intensified, prevail at the property of the Telkwa Mining, Milling and Development Company, situated on Coal creek, a small stream running into Goldstream one of the headwaters of the Morice river, and not far from the head of the south fork of the Telkwa river; here a number of seams of good coal have been opened up. The disconnected nature of the work done, with the disturbed condition of the strata, renders it almost impossible to be sure of the relative positions of the seams, and whether several of the openings are on the same or different seams. It is fairly certain, however, that at least four different workable seams have been uncovered. In descending order these have the following respective thicknesses:— Four feet two inches, four and one half feet, four feet, and seven

feet three inches. Analyses of the second, third and fourth of these seams resulted as follows:—

	Moist.	Vol. Com. Mat.	Fixed Carbon.	Ash.
No. 1.—4½ foot seam.................	1.36	10.87	80.82	6.95
No. 2.—4 foot seam..................	0.58	10.82	82.70	5.90
No. 3.—7 ft. 3 ins. seam.............	0.80	11.10	78.90	9.20

All of the above coals are non-coking and, like those from the Transcontinental Syndicate's property, can be classed as semi-anthracite. They are all strong, bright and lustrous.

Where these seams have been uncovered the area of coal-bearing rocks is very narrow, probably not more than a few hundred feet in width. It appears to lie on the line of, and on the downthrow side of, a fault which is parallel to, and near the axis of, a sharp syncline, and represents a small remnant of a once much larger coal-field now mostly removed by erosion. The southern boundary of this coal area was not determined and it is probable that to the south and west, in the main valley of Goldstream, a much wider belt of coal land will be found to exist.

GENERAL CONCLUSION.

With regard to this field as a whole, it may be said that wherever the coal formation has been exposed faults were seen, not, as a rule, of any great size, but in such numbers as to be a matter of serious importance to future mining operations. The coal has also been cut by numerous dikes, and nearly everywhere is somewhat severely flexed. These facts, taken in connexion with the uncertain extent of several areas, seem to render it imperative that systematic and careful prospecting should be undertaken well in advance of regular mining. Some method of boring could possibly be utilized to determine the position and the nature of the strata underlying the great gravel deposits of the terraces; until something of this sort is done it will be impossible to define the limits of the several coal areas with any degree of accuracy. It is possible that in certain cases mining could be successfully carried on by stripping the overlying gravel and shales from the coal, when not of too great depth, a method that was formerly

somewhat extensively utilized in the anthracite fields of Pennsylvania.

Coal has been reported as occurring in the bed of a small creek entering Burnie lake from the east, and also in a small tributary of Pine creek, and it is quite possible that other small basins will be found when the country has been more thoroughly prospected.

Nearly all the faults noted, especially in the coal areas on Goat and Mud creeks, were normal ones with downthrows to the south and west.

MINERAL CLAIMS.

Hunter basin, situated at the head of Cabin or Four-mile creek, a tributary of Goat creek, was the first locality visited. The country rock here consists of bedded volcanic rocks, red and greenish andesites, agglomerates, &c., tilted at comparatively low angles, but occasionally showing locally more severe crumpling, often accompanied by faulting. Across the ridge to the south, at the head of Glacier and Webster creeks, an intrusive area of coarsely-crystalline granitic rocks is found which seems to have had an important relationship to the mineralization of the district, as it is along the borders of this area that many claims have been staked, notably in Hunter basin, Hankin basin, Dominion basin (at the head of Goldstream), and various locations on the heads of Sunrise and Glacier creeks. The eruptive mass is itself in places impregnated with iron pyrites, which has resulted in the weathering of the rocks to a bright rusty yellow, giving a characteristic colouring to the mountains.

In Hunter basin the veins are, as a rule, small, and appear either in narrow irregular fissures or as replacements along lines of crushing. The 'King' and 'Rainbow' claims are good examples of the former. On the 'King' a shaft had been sunk, said to be fifty feet in depth, but full of water when seen. The vein, at this point, is about two and one-half feet wide and is in places well mineralized with bornite and chalcopyrite, the ore occurring in irregular lenses or pockets; it is reported to carry good values in silver and copper.

On the 'Rainbow' ore of a different class is found, consisting chiefly of highly micaceous specular iron with some iron pyrites, bornite, chalcopyrite and copper carbonates. There appear to be two or more small irregular veins, more or less parallel. Where the most work had been done on one vein it varied from one to ten inches in width, practically all ore.

On the 'Waresco' claim the ore seems to occur along a crushed zone from four and a half to five feet in width, the country rock having been decomposed and replaced in part by minerals consisting of copper carbonates, copper glance, chalcopyrite and bornite.

Numerous other claims of a similar nature are to be found in this neighbourhood, but very little work has as yet been done in proving them.

Dominion basin at the head of Goldstream is near the opposite border of the Glacier Creek granite area. The country rock here is composed of grey and greenish volcanics not so much disturbed as at Hunter basin, but with generally regular light dips to the southwest. These rocks are cut by a fine-grained, brownish-coloured dike, about forty-five feet in width, which can be plainly seen on both sides of the valley which it crosses about at right angles. It is along the edges of this dike that various mineral claims have been staked, the Dominion and the Black Jack being the most important. It would appear that this dike has afforded a channel for the ascent of the mineral-bearing solutions which have penetrated laterally along the bedding planes of the volcanics, where most readily attacked, decomposing and replacing the country rock in part with secondary minerals and ore. It seems reasonable to suppose, therefore, that the ore bodies will be found to occur in a succession of steps, where the more readily decomposed strata of the volcanics are met with, and will reach their maximum thickness in the intermediate neighbourhood of the dike, gradually disappearing at increased distances from it. The ore consists chiefly of micaceous specular iron, chalcopyrite, copper glance and copper carbonates with a gangue of altered country rock, quartz, calcite and epidote.

Another and larger area of intrusive rocks occurs near the head of Scallon creek, an important tributary to the south fork of the Telkwa from the west, extending across the divide to the headwaters of the Morice and main branch of the Telkwa. This rock has sent out numerous dikes in all directions into the surrounding volcanics, and has also caught up and included in it many patches of the latter. Near the contact of these two formations, and along the dikes from the former, a large number of mineral locations have been made including the Duchess, the Anna-Eva and the Evenings groups on Howson creek, the Starr group on Starr creek and numerous other claims.

The Duchess group owned by the Telkwa Mines, Limited, is situated on the north side of Howson creek near its head. This property has been opened up by a short tunnel about twelve feet

long, all in ore. The ground in the vicinity is rather heavily drift-covered and, as yet, but little work has been done, so that it is very difficult to gain an idea of the nature of the deposit. It appears probable, however, that the ore occurs in a large dike from the neighbouring eruptive rocks at or near its contact with the volcanic country rock, the volcanics themselves, near the dike, being largely decomposed and in places mineralized and with much epidote developed. The extent of the ore body is not yet shown, but at the entrance to the tunnel it is at least twelve feet wide and can be traced longitudinally for several hundred feet, the whole mass being more or less highly mineralized with pyrites, chalcopyrite and hematite, weathering to a well-defined iron-cap on the surface. The gangue consists largely of the decomposed and highly altered dike rock with many small quartz stringers parallel to the dike walls.

A short distance down the creek, on the same side, the Evening group is situated, the property of the Telkwa Mining, Milling and Development Company. This appears to be of a very similar nature to the Duchess, but the hillside here being less heavily drift-covered the ore can be traced more readily. The mineral apparently is contained in a dike from twenty-five to thirty feet in width, cutting at a narrow angle the bedded volcanics, which are here tilted at high angles and in places much altered; the whole width is more or less mineralized with irregularly distributed lenses and bands of higher grade ore, as in the Duchess, consisting of chalcopyrite, pyrite and hematite with a large quantity of quartz and remnants of the original dike rock. This deposit has been opened up by cuts at irregular intervals for a distance of about 1,500 feet, in all of which ore is shown.

On the ridge on the opposite side of Howson creek, and consequently farther away from the eruptive rocks, a number of claims have been staked including the Anna-Eva group, the Iron-Horse group, the War Eagle, Granville, Strathcona, Homestake, Walter and many others. All of these show a somewhat similar condition of affairs to that noted at the Duchess and Evening; the mineral occurring in dikes, in streaks parallel to, and generally richer near, the walls, and usually associated with quartz, serpentine, calcite, epidote and other secondary minerals. In places the volcanic country rock is likewise decomposed and mineralized alongside of the dikes. None of these claims appear to be so heavily mineralized as are those across the creek.

Across the ridge, at the head and to the west of Howson and Scallon creeks, in Starr basin, a number of claims are located. The ore here is usually found at the contact of the eruptive and

volcanic rocks. This contact is very irregular in outline as the volcanics have been much shattered, and many patches of varying size have been caught up in the intrusive rocks; these small areas are usually highly altered and often somewhat mineralized.

At the Starr group the ore seems to be developed along two parallel crushed zones in the volcanic near the contact, about two and three feet in width, respectively. The mineral, which is irregularly distributed, consists of pyrite, chalcopyrite and copper carbonates, in a gangue of quartz, calcite and altered country rock.

At the time of the writer's visit practically no work had been done on any of the Telkwa River properties beyond mere surface prospecting, and that to a very limited degree only. In some of the small fissures high grade ore is found, with values chiefly in silver and copper, the gold contents being as a rule small throughout the district. It is, however, mainly in the larger and lower grade properties that the future of this country depends, but, until much more work has been done little idea of the extent of the deposits and their ultimate value can be gained. As none but smelting ores have so far been discovered, and as they are not of sufficiently high grade to stand transportation in existing circumstances, no great development need be looked for until the advent of the railway.

Although time was not available to visit the headwaters of the Zymoetz river or the Babine mountains, where many claims have been located, it may be of interest to note here that many promising specimens of galena ore, said to be from those localities, were seen by the writer.

ADDENDA

Since the foregoing was written, the writer has spent another season in the Telkwa district, and obtained some additional information, the chief points of which are embodied in the following notes.

TOPOGRAPHY.

The Telkwa, above the south fork, occupies a wide flat valley, the river meandering through swampy meadows, following a course approximately northeast and southwest. About twelve miles from the south fork, near Milk creek, the valley turns sharply to the south, and, at the bend, an unexpected, low pass leads off westward to Summit creek, a branch of the Zymoetz. This pass has an elevation of about 1,300 feet above the mouth of the Telkwa, and may prove of great importance; as the Grand Trunk Pacific have found a feasible railway route through it, which, if used, will shorten considerably the distance from the mouth of the Telkwa to the coast.

Milk creek rises in a high and rugged range of mountains, forming the divide between the Zymoetz, and Telkwa rivers. This range rapidly decreases in height to the east, forming a plateau-like country, where the highest point reaches an elevation of only 6,600 feet, finally dropping down to a low pass, in which Pass creek rises and separates it from the Hudson Bay mountains.

The last named range, though quite rugged—the highest points reaching at least 8,000 feet—is cut off on all sides by low country, and forms a very conspicuous feature of the district.

In most cases the headwaters of the Zymoetz occupy wide, flat valleys, interspersed with many small lakes, and much meadow land.

TRANSPORTATION.

Last summer, a good cable ferry was put in across the Bulkley river, above the mouth of the Telkwa, and a commencement made on the construction of a bridge nearby; while the Provincial Government have built a sleigh road from Hazelton to Aldermere, thus greatly improving the means of access to this district.

MINERAL CLAIMS.

Comparatively few new claims were staked last season, and chiefly assessment work done on those already located, hence

little can be added to what has already been said. There are, however, a few claims that were not visited before, also some new points of interest on those already described, which may be nentioned here.

At Hankin's camp, near the head of Goat creek, is situated a group of claims belonging to Messrs. Loring, Forrest, and the Hankin Brothers. These are among the oldest mineral locations in the district, and are partially prospected by open cuts and several short tunnels.

The country rock consists of typical beds of volcanics, tuffs, agglomerates, andesites, &c., belonging to the Porphyrite group and here lying nearly horizontal and well exposed at many places on both sides of the rather deep, narrow valley. These beds are cut by a number of roughly parallel, light-coloured quartzose dikes with a nearly vertical dip, and crossing the valley approximately at right angles.

The mineral deposits occur in nearly horizontal beds following the bedding planes of the volcanics, and show decided enrichment in the immediate vicinity of the dikes; the mineral-bearing solutions having apparently ascended along the walls of the dikes, and thence following the bedding planes, have decomposed the more readily attacked volcanic beds.

On the "Eldorado," "Naiad" and "Telkwa" claims, the best showings of mineral are to be met with; here at least three beds of ore, each about five feet in thickness, may be seen, consisting of iron pyrites, copper pyrites, a little pyrrhotite, hematite and magnetite, in a gangue of altered country rock, calcite, epidote, garnets, quartz, &c. The percentage of copper is small, but, according to the owners, fair values in gold are to be found. The ore bodies are very much thicker in places, more particularly alongside of the dikes.

On Howson creek, at the "Evening" claim, a cross-cut of seventy feet has been run in low grade ore, the main body, exposed by cuts on the surface, not having yet been reached.

On the "Duchess," a tunnel has been driven for sixty feet, starting at a very good exposure of copper ore and following the foot-wall of the ore-bearing dike. The ore is continuous for the length of the tunnel. Several open cuts have been made up the hill on what is supposed to be the "Duchess" dike; one of these shows six feet of good ore, the others very little, but the dike is much decomposed and iron-stained.

There are a number of parallel dikes here, some of them ore-bearing, which have a general north and south strike, about at right angles to the direction of the valley. As the ground is mostly drift-covered, and the dikes are often quite close to one another, it is a difficult problem to ascertain, for any distance, which dike one is following.

The "Countess" claim, owned by the same company as the "Duchess", (The Telkwa Mines, Limited) is situated near the top of the ridge on what is probably a similar and parallel dike. An open cut has been made here, but not much ore is in sight; a small cut, however, on the same dike at the top of the ridge,

has a much better appearance, the ore there being similar to that at the "Duchess."

Across the ridge, to the north, in a small basin in which rises a branch of Howson creek, a number of claims have been staked. Among these the "Standard," "Princess," and "Contention," are also owned by the Telkwa Mines, Limited; on only one of these, the "Standard," was any work seen. It consisted of a small open cut showing from eighteen to twenty inches of good ore, composed of chalcopyrite and specular iron with a little quartz. The ore occurs in a dike along the hanging wall.

In this basin, as at the "Evening" and "Duchess," a number of parallel dikes occur, with approximate north and south strikes cutting the bedded volcanics. The ore found in the dikes is usually near the walls, and at times extends into the country rock.

The Telkwa Mining, Milling and Development Company have also a number of claims here, among others the "Whispering Wind" and "Silver Heels." On the latter, a large dike from fifty to sixty feet wide exists, striking north and south, and dipping 75 to 80 degrees east. On the easterly or hanging wall, about four feet of chalcopyrite and specular iron ore was seen, but no work has been done. On the westerly wall, however, a large open cut shows fifteen feet of good ore, consisting of chalcopyrite, specular iron, and a little iron pyrites with a gangue of quartz and altered country rock.

COAL.

On the coal properties mentioned in the earlier part of this report nothing has been done, practically, since our previous description was written, the owners awaiting the advent of the proposed railway before resuming operations.

On Goldstream, however, a little below its junction with Coal creek, and separated from the property of the Telkwa Mining, Milling and Development Company by a short distance only, a new coal area was discovered last year.

This area, about two, by two miles and one-half, at its greatest diameters, is in the form of a basin, the coal outcropping on both sides, at from 400 to 500 feet above the floor of the valley. The coal dips towards the creek from both sides, with a slope rather greater than that of the hills, so that it underlies the bed of the stream, although at no great depth.

Up Goldstream this area is separated from that of Coal creek, probably by an anticline, the coal measures having been removed from its axis by denudation. At the lower end, the limits of the coal-bearing strata are not so closely defined, but, in all probability, the creek has there cut through the coal measures to the underlying volcanics, this cutting being accentuated by another anticlinical fold.

The coal has been opened up at only one place, where two seams have been uncovered, the upper one showing five and

one-half feet of clean coal, overlain by about one and one-half feet of soft, impure coaly material, the cut not having been extended far enough to locate the roof clearly. The lower seam shows three and one-half feet of clean, bright coal. No analyses have as yet been made of these coals, but in appearance they closely resemble the coal from Coal creek. At several other points across the basin the coal outcrop was noted, but no time was available to open up the seams.

No evidences of local disturbances or faulting of any great extent were noted.

Another and smaller area was seen about two miles farther down Goldstream, but has not been opened up.

Other areas of the coal-bearing rocks were noted at Driftwood creek, Moricetown, at the head of the Zymoetz river, and on Hudson Bay mountain, but at none of these localities has any workable seam been yet found, and it seems probable that the seams reach their maximum thickness in the Telkwa-Morice River district, and thin out rapidly, at least towards the north.

It is now fairly certain that no great coal field exists in the Bulkley Valley district, from Hazelton to the headwaters of the Morice, but many comparatively small, isolated areas are known, in which the coal varies from a lignitic to a semi-anthracite. In some of these areas the strata are greatly disturbed, much faulting and folding being in evidence.

The quality of the coal seems to depend on the proximity of the measures to the newer eruptive rocks, which are younger than the coal, and in places have sent out dikes cutting the seams.

A number of fossils were collected from the coal measures and adjacent beds; although none of these have as yet been determined, there is sufficient evidence to state that these rocks are probably Lower Cretaceous, though possibly Jurassic.

NEW BRUNSWICK AND NOVA SCOTIA.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. (20c.)
219. Carleton and Victoria cos., by L. W. Bailey. 1885. (20c.)
242. Victoria, Restigouche and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. (10c.)
243. Guysborough, Antigonish, Pictou, Colchester and Halifax counties, N.S., by Hugh Fletcher and E. R. Faribault. 1886. (25c.)
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-88. (25c.)
330. Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890-91. (10c.)
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